Volume 107
Article 08

SEPTEMBER 1997

KOOTENAI RIVER WHITE STURGEON INVESTIGATIONS

Chapter 1: Kootenai River White Sturgeon Spawning and Recruitment Evaluation

Annual Report 1996

BONNEVILLE POWER ADMINISTRATION

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

For additional copies of this report, write to:

Bonneville Power Administration
Public Information Center - CKPS-1
P.O. Box 3621
Portland, OR 97208

Please include title, author, and DOE/BP number from the back cover in the request.

KOOTENAI RIVER WHITE STURGEON INVESTIGATIONS

CHAPTER 1: KOOTENAI RIVER WHITE STURGEON SPAWNING AND RECRUITMENT EVALUATION

ANNUAL REPORT 1996

Period Covered: January 1,1996 to December 31, 1996

Prepared by:

Vaughn L. Paragamian, Senior Fisheries Research Biologist
Gretchen Kruse, Senior Fisheries Technician
Virginia Wakkinen, Fisheries Technician

Idaho Department of Fish and Game
Boise, ID 83707

Prepared for:

U. S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

IDFG 97-27
. Project Number 88-065 Contract Number 88BI93497

SEPTEMBER 1997

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF APPENDICES

LIST OF APPENDICES (Cont.)

LIST OF APPENDICES (Cont.)

ABSTRACT

Test flows for Kootenai River white sturgeon *Acipenser transmontanus* spawning, scheduled for June 1996, were postponed until July. However, an estimated 126% snow pack and unusually heavy precipitation created conditions for sturgeon spawning that were similar to those occurring before construction of Libby Dam. Discharge in the Kootenai River at Bonners Ferry rose to nearly 1,204 m^3/s (42,500 cfs) during May and water temperature ranged from 5.8°C to 8.4°C (42°F to 47°F). Migration of adult white sturgeon into spawning areas occurred in late May during a rising hydrograph. Discharge and water temperature were rising and had reached approximately 1,077 m^3/s (38,000 cfs) and 8°C (46°F). Discharge at Bonners Ferry peaked at about 1,397 m^3/s (49,300 cfs) on June 5. A total of 348 eggs (and one egg shell) were collected with 106,787 h of mat effort during the flow events. The first white sturgeon eggs were collected on June 8 and continued through June 30. Staging of eggs and back-calculating to spawning dates indicated there were at least 18 spawning episodes between June 6 and June 25. Discharge on June 6 was 1,196 m^3/s (42,200 cfs) and decreased steadily to 850 m^3/s (30,000 cfs) by June 26. Although sturgeon spawned in the same reach of river that they had during 1994 and 1995, the majority of eggs were found significantly (P=0.0001) farther upstream than 1994 and 1995 and this in turn may be related to elevation of Kootenay Lake. Average age of eggs collected in 1996 was significantly older (P=0.0001) than those collected in 1994 and 1995. We used mark and recapture data from fish in the Kootenai River from Bonners Ferry downstream and including Kootenay Lake to estimate an adult population of 1,469 (740 to 2,197) sturgeon and 87 wild juveniles in 1995. We recommend a test flow for 1997 that is similar in magnitude to that of 1996. It should begin when river temperature approaches 9°C (48°F) and should be in increments of 57 m^3/s (2,000 cfs) per day to a minimum of 709 m^3/s (25,000 cfs) from Libby Dam. We also recommend no load following. It is also advisable to test the hypothesis that spawning in suitable habitat correlates directly to elevation of Kootenay Lake.

Authors:

Vaughn L. Paragamian
Senior Fishery Research Biologist

Gretchen Kruse
Senior Fishery Technician

Virginia Wakkinen
Fishery Technician

STUDY SITE

The Kootenai River originates in Kootenay National Park, British Columbia, Canada. The river flows south into Montana and turns northwest at Jennings, the site of Libby Darn, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 40 km (24.8 mi) below Libby Dam, is thought to be an impassable barrier to sturgeon. As the river flows through the northeast corner of Idaho, there is a transition at Bonners Ferry. Upriver from Bonners Ferry, the channel has an average gradient of .6 m/km (3.15 ft/mi) and the velocities are often higher than .8 m/s (2.6 ft/s). Downriver from Bonners Ferry, the river slows with velocities less than .4 m/s (1.3 ft/s), average gradient is .02 m/km (.1 ft/mi), the channel deepens, and the river meanders through the Kootenai Valley. The river returns to British Columbia at rkm 170 and enters the south arm of Kootenay Lake at rkm 120. The river leaves the lake though the west arm to its confluence with the Columbia River at Castlegar, British Columbia. A natural barrier at BonningtonFalls (now a series of four dams), has isolated the Kootenai white sturgeon from other populations in the Columbia River basin for approximately 10,000 years (Northcote 1973). The basin drains an area of 49,987 km^2 (19,300 mi^2) (Bonde and Bush 1975).

Impounding the Kootenay River with Libby Dam reversed the natural hydrograph (Figure 2). However, since 1991, mitigative flows have changed the hydrograph of the Kootenai River from pre- and post-Libby Dam years (Figure 2).

OBJECTIVE

Determine environmental requirements for adequate spawning and recruitment of white sturgeon by 1998.

METHODS

Discharge and Water Temperature

Kootenai River discharge and water temperature data at Bonners Ferry and discharge from Libby Dam were obtained from the U.S. Army Corps of Engineers (USACE). An experimental flow was proposed jointly by the U.S. Fish and Wildlife Service (USFWS) and USACE to enhance white sturgeon migration and spawning. The proposed flow was to have three peaks starting in mid-May and extending into early July. Each peak in flow was to be about 907 m^3/s ([32,000 cfs] conversions to cfs are rounded to hundreds) at temperatures of 10°C, 12°C, and 14°C (50°F, 53.6°F, and 57.2°F). Temperature was to be controlled by manipulating the location of water withdrawn from Libby Dam.

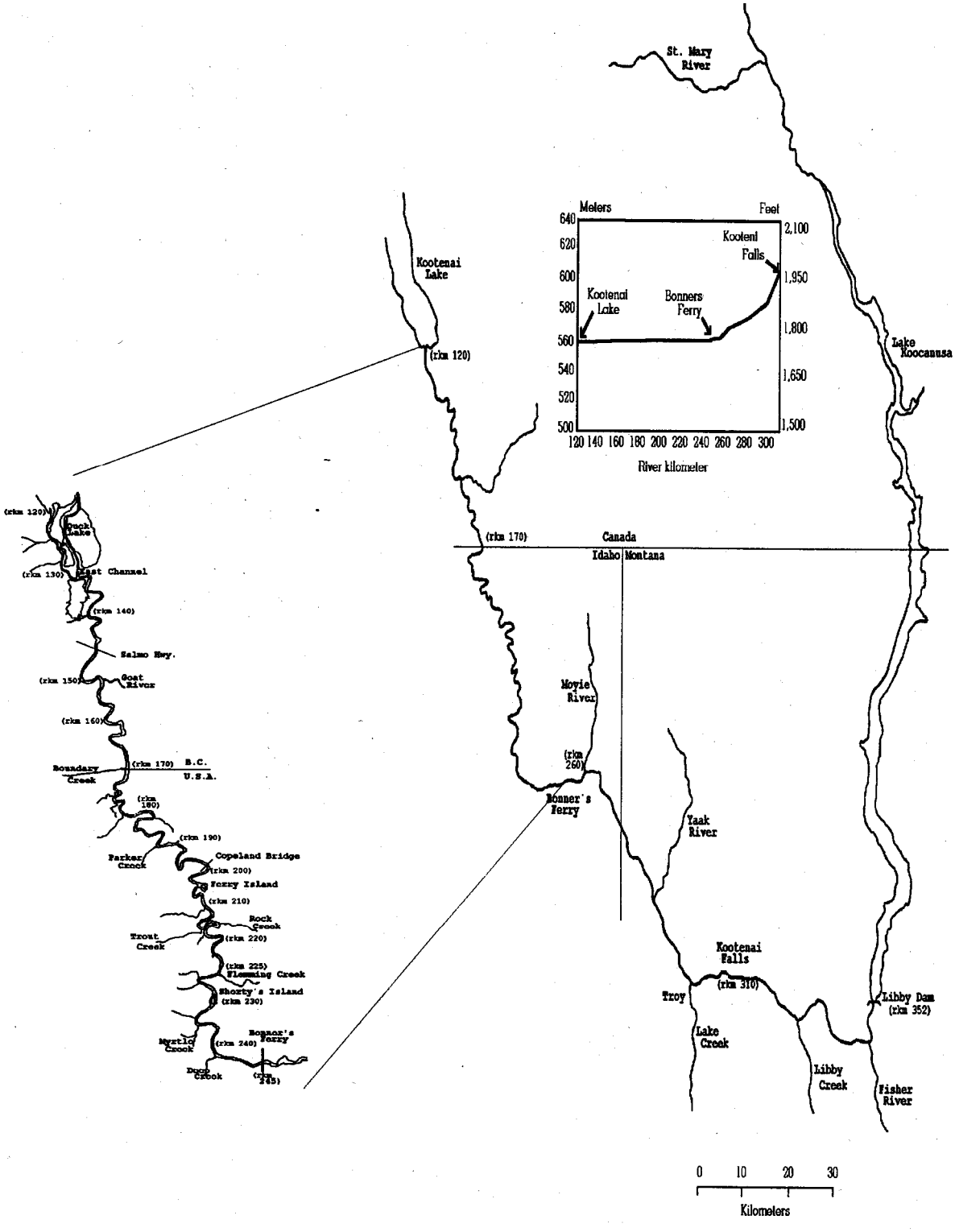


Figure 1. Map of the Kootenai River with a schematic of river gradient and notable points of reference from Bonners Ferry to Kootenay Lake. Complete study area was from southern Kootenay Lake upriver to Kootenai Falls.

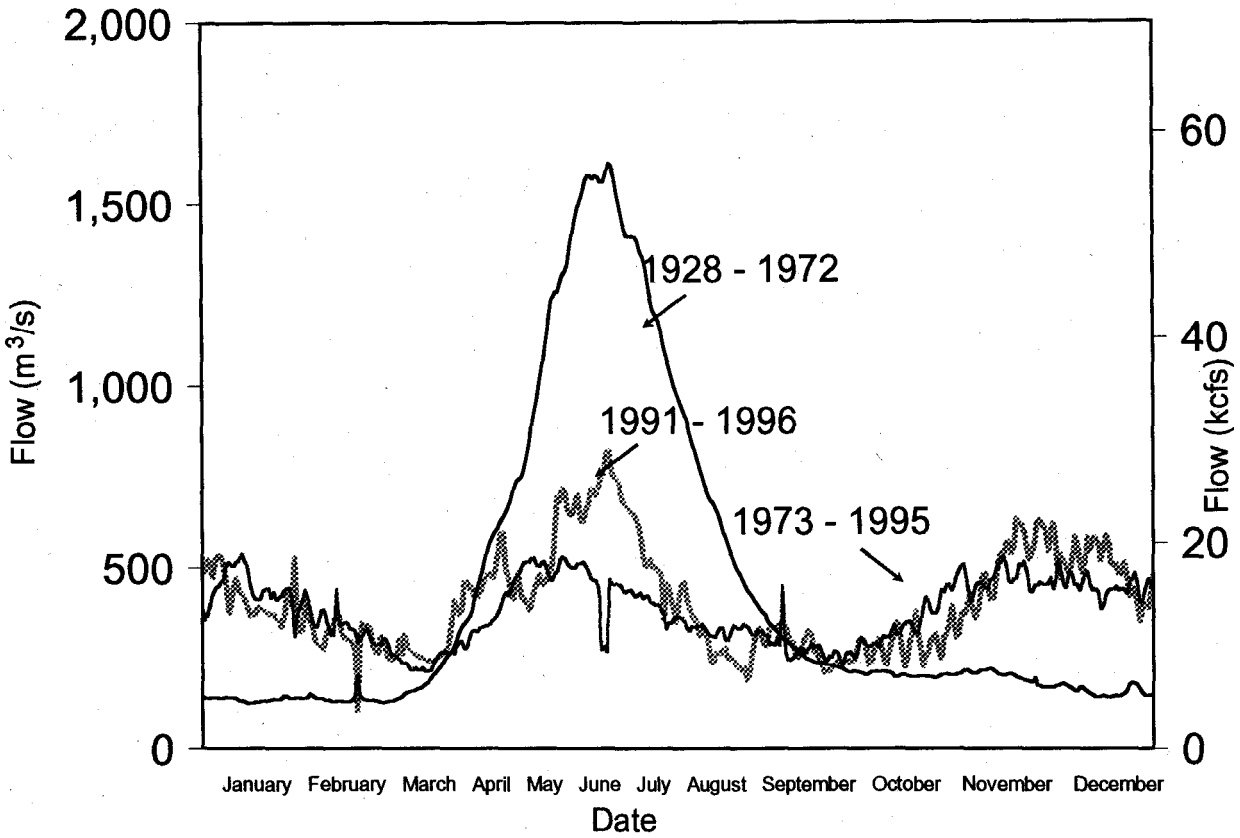


Figure 2. Mean monthly flow patterns in the Kootenai River at Bonners Ferry, Idaho from 1928 - 1972 (pre-Libby Dam), 1973 - 1990 (post-Libby Dam), and 1991 - 1996 (post-Libby Dam with augmented flows).

Exceptionally heavy precipitation and 126% snow pack in the drainage prevented the anticipated tests (see Results section). As a consequence water management at Libby was primarily for flood control for the Kootenai River valley. Thus, monitoring and evaluation of white sturgeon spawning occurred during a near natural hydrograph.

Adult White Sturgeon Sampling

Adult white sturgeon were captured with rod and reel or set lines from August 1, 1995 to August 31, 1996. Sampling was carried out in accordance to methods cited in Paragamian et al. (1996). Some adult white sturgeon were tagged with radio and sonic tags and monitored to determine movement during the spawning season (Paragamian et al. 1996).

Adult White Sturgeon Telemetry

Movement and migration of adult white sturgeon fitted with sonic and radio transmitters were monitored monthly from a boat in the Kootenai River and Kootenay Lake, from Bonners Ferry to the north end of the lake. The main objective was to locate late vitellogenic females and males migrating upstream to staging and spawning reaches. As sturgeon activity increased, monitoring effort increased. Each transmitter location was recorded to the nearest .1 river kilometer (rkm) (.061 mi). Surface water temperature was measured daily with a hand-held thermometer.

Effort required to monitor transmitters varied with season. Less effort was required during winter months when most fish moved less frequently than in spring and fall. Increased activity among tagged fish during the pre-spawning and spawning seasons required more frequent monitoring. Upriver reaches were monitored more intensively than downriver or lake sections, especially during the pre-spawning and spawning periods when mature sturgeon moved upstream.

A fixed-location receiver was stationed upriver (rkm 245.6) from May 23 to July 22 to detect fish movements above Ambush Rock (rkm 244.5). Radio frequencies of suspected spawners were programmed into the receiver and checked daily.

Fixed-wing aerial telemetry of radio-marked fish was accomplished on two separate occasions, June 12 and July 9. An omni-directional whip antenna was mounted on the belly of a Cessna 182 for the first attempt. Tracking ability was improved the second trip using a directional loop antenna mounted under one wing. During both trips, we slowly flew a course downriver from Bonners Ferry to Kootenay Lake at various altitudes from 152 to 915 m (500 ft to 3,000 ft). Pre-set radio frequencies were taken out of the receiver as they were detected.

White Sturgeon Egg Sampling

We used artificial substrate mats to document white sturgeon spawning (McCabe and Beckman 1990, Paragamian et al. 1996). Eggs were collected, preserved in an alcohol and glycerine solution, and staged according to Paragamian et al. (1996).

As many as 100 mats were deployed in the river from Lower Shorty's Island (rkm 228) to Bonners Ferry (rkm 248) between May 6 and July 19, 1996. This river reach (rkm 228-248) was divided into 13 sections based on distinct habitat features. The 13 sections are as follows: Lower Shorty's Island (rkm 228-229.5), Middle Shorty's Island ([rkm 229.6-231.5] a 1 km reach from rkm 230-231 was not sampled because it was a broodstock collection reach for the Kootenai Tribe of Idaho [KTOI]), Upper Shorty's island (rkm 231.6-233.4), Myrtle Creek (rkm 233.5-234.7), Refuge (234.8-237.5), Deep Creek (237.6-240.5), Hatchery (rkm 240.6-243.9), Ambush Rock (rkm 244-244.6), US Highway 95 (rkm 244.7-246.4), and Upper Pump Station (rkm 246.7-247.7).

Juvenile White Sturgeon Samplina

Weighted multifiliment gill nets with 2.5 to 5 cm (1-2 in) mesh and shrimp trawls were used to sample juvenile and young-of-the-year (YOY) sturgeon (Paragamian et al. 1996; Fredericks and Fleck 1996). Gill nets were fished at various locations between Ambush Rock (rkm 244.5) and Kootenay Lake (rkm 118). They were set during the day and checked every hour. Shrimp trawls were towed in a downriver direction in order to minimize hanging up on snags. Juvenile white sturgeon were processed according to methods cited in Paragamian et al. (1996).

Juvenile White Sturgeon Telemetry

Hatchery released juvenile white sturgeon with active sonic tags (Marcuson et al. 1995; Paragamian et al. 1996) were tracked to document movement and habitat use. We assumed habitat choice of hatchery juveniles could be an indicator of habitat selection in wild juvenile sturgeon.

Age and Growth of White Sturgeon

Ages of adult and juvenile white sturgeon were determined by pectoral fin ray analysis (Marcuson et al. 1995; Paragamian et al. 1996). Age information was used to determine year class structure.

White Sturgeon Population Estimates

Population estimates using a computer programed Seber-Jolly (Ricker 1975) method were calculated for adult and juvenile (wild and hatchery) white sturgeon. The estimates were based on the mark and recaptures of all white sturgeon handled since investigations of sturgeon in the Kootenai River began and the method employs a sampling effort variable for the study reach. The estimate included the river from Bonners Ferry downstream to and including Kootenay Lake because these were the only waters we sampled. Some white sturgeon are known to be above Bonners Ferry, but their numbers are considered to be very few in comparison to the total. The Seber-Jolly method is based on multiple sampling and provides estimates for all time intervals except the first and last (Ricker 1975). The Seber-Jolly method also provides an estimate of annual survival.

Larval Sturgeon Sampling

We used sub-surface meter net tows, passive D-ring sets, and shrimp net trawling to search for larval white sturgeon in the Kootenai River and Kootenay Lake. A mid-water trawl was also used in the South Arm of Kootenay Lake concurrent to our studies by the British Columbia Ministry of Environment Fisheries (BCMOE) (Robert Lindsay, BCMOE, personal communication) and a beam trawl by researchers from Montana Department of Fish, Wildlife, and Parks (MDFWP). Sampling for burbot was simultaneously performed to facilitate a companion study (Paragamian and Whitman in press).

We used two techniques for meter net sampling. In the Kootenai River, sub-surface tows were made during daylight periods from April 3 through August 20, 1996. Tows were made between rkm 121 and rkm 239. Most meter net tows in the river were between rkm 191 and rkm 237 (in the vicinity of sturgeon egg collections or downstream). In Kootenay Lake, we sampled biweekly with paired tows at four transect sites (four daylight samples and four night samples) in the South Arm (rkm 118-119) from March 20 through August 7. Site one started about 400 m (1,300 ft) offshore from the Kuskanuk Boat Ramp, depth of Kootenay Lake was about 75 m (250 ft), and each of the remaining consecutive sites continued from east to west. The four sample sites covered about 80% of the width of Kootenay Lake in the South Arm. Site three was due north of the Kootenay River delta mouth. The meter net was towed for a period of 16 to 20 minutes (see Fredericks and Fleck 1996 for a more detailed description). Paired sampling was carried out to test the hypothesis that nighttime sampling would yield more larval fish (including-sturgeon) than the daytime samples (Pitlo et al. 1995).

D-rings were lowered to the river bottom by a winch and set for a duration of about 2 h for passive sampling. D-ring samples were taken from rkm 217 to rkm 237 during mid-summer.

Shrimp net trawling was restricted to the Kootenai River (rkm 175 through 231.6). Sampling was performed during daylight hours from August 12 through September 4, 1996. The shrimp trawl provided the opportunity to sample the bottom of the river with a gear that would be selective for "fingerling" sized sturgeon and burbot. For more specific sampling details see Fredericks and Fleck (1996).

Laboratory Egg Development and Sand Test

We designed a test to determine the effect of a sand coating on the development of white sturgeon eggs. Many white sturgeon eggs collected in the Kootenai River in 1994 and 1995 were coated with coarse sand. Five-hundred eggs from cultured white sturgeon at the Kootenai Indian Tribal Hatchery were used in the experiment. The experiment was designed to test the hypothesis that survival and development of white sturgeon eggs is not reduced by a coating of course sand. Two equal lots each of control eggs de-adhesed with Fullers Earth (eggs are normally de-adhesed with Fullers Earth in culture) and test eggs de-adhesed with coarse sand were to be placed in egg jars. All eggs were incubated on city water. A sample of 25 eggs from each jar were taken at eight-hour intervals to determine fertility and then each eight-hour interval thereafter to determine egg stage.

RESULTS

Discharge and Temperature

Test flows for Kootenai River white sturgeon spawning scheduled for June 1996 were postponed until July. However, an estimated 126% snow pack and unusually heavy precipitation created near normal conditions for sturgeon spawning. Discharge in the Kootenai River at Bonners Ferry rose to nearly 1,204 m^3/s (42,500 cfs) during May and the water temperature ranged from 5.8°C to 8.4°C (42°F to 47°F) (Figure 3). Discharge in early June continued to rise and reached a peak of 1,397 m^3/s (49,300 cfs) at Bonners Ferry by June 5. Discharge from Libby Dam during June was usually at maximum capacity of 765 m^3/s (27,000 cfs). Discharge at Bonners Ferry dropped to 1,196 m^3/s (42,200 cfs) and decreased steadily to 893 m^3/s (31,500 cfs) by June 25. Temperature was steadily increasing from 9.1°C to 11.2°C (48°F to 52°F). Discharge was gradually reduced to facilitate two test flows. The test flows incorporated temperature increases that were produced by selective water withdrawls from Libby Dam.

By July 1, discharge at Bonners Ferry decreased to 561 m^3/s (19,800 cfs) and temperature was 12.4°C (54°F). On July 1, the USACE initiated the first of two test flows

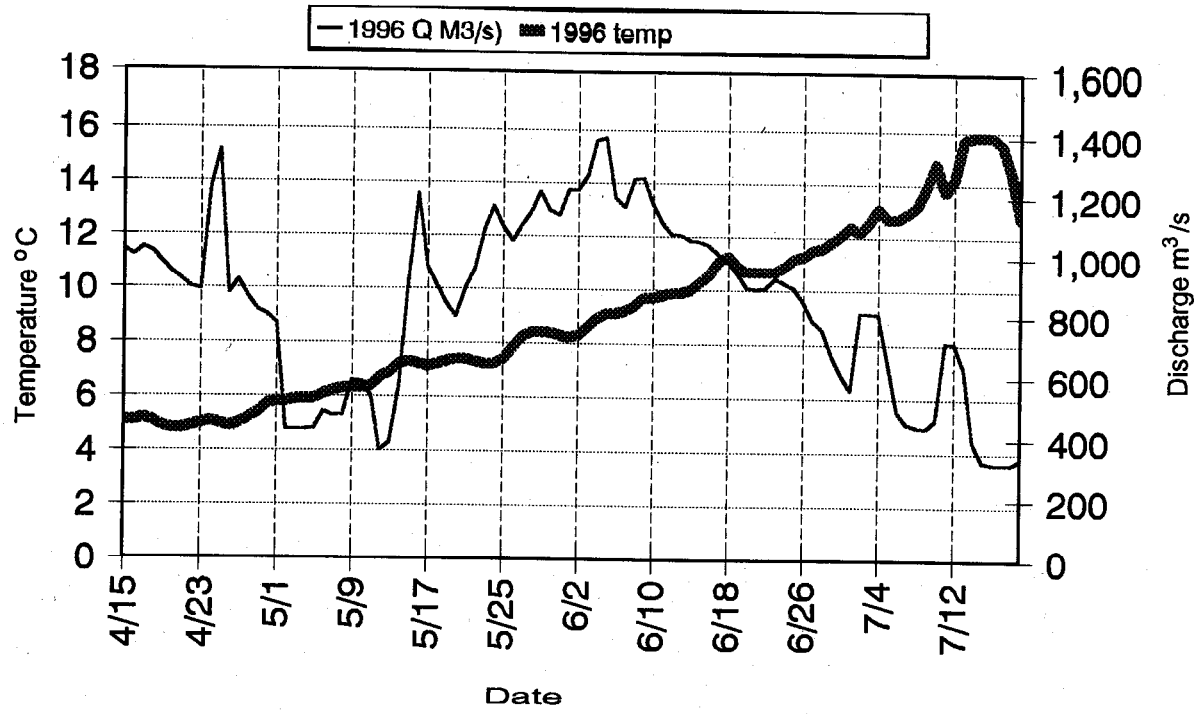


Figure 3. Temperature (°C) and flow (m^3/s) in the Kootenai River at Bonners Ferry, Idaho, 1996.

and increased discharge at Libby Dam, which increased flow at Bonners Ferry to 813 m^3/s (28,700 cfs). Concomitant, by discharging warm water from near the surface of Lake Koocanusa temperature was increased to 13.1°C (56°F) by July 4. On July 5, the first test flow was completed, and discharge at Bonners Ferry was reduced to 652 m^3/s (23,000 cfs) and temperature was 12.7°C (55°F). Discharge continued to decrease to 440 m^3/s (15,500 cfs) by July 9. The following day, discharge was increased again and peaked at 719 m^3/s (25,400 cfs) on July 11. At the same time temperature increased to 15.7°C (60°F). Discharge was again reduced in anticipation of water ordered by the National Marine Fisheries Service for salmon in the Columbia River.

Adult White Sturgeon Captures

Two hundred twenty-five adult white sturgeon were captured between August 1, 1995 and August 31, 1996; 53 by the KTOI, 118 by BCMOE, and 54 by Idaho Department of Fish and Game (IDFG) researchers (Appendix A). We expended 1,743 hours of effort using angling and set line gear to sample 50 adults (Table 1). Four additional adult white sturgeon were captured in gill nets while sampling for juveniles for a total of 54. Twenty-two (41%) of the 54 sturgeon captured by IDFG and 69 (40%) of the remaining 171 fish caught by other agencies were recaptures (Appendix A).

Catch per unit effort (CPUE) for adult sturgeon caught by angling and set line gear was .07 and .03 fish/h, respectively. Catch per unit effort for adults caught in juvenile gill nets was .01 fish/h (Table 1).

A total of 99 biopsies were performed on adult sturgeon by IDFG, KTOI, and BCMOE to determine sexual maturity stage of ovaries and testes (24 females, 58 males, and 17 unknown) (Appendix B). Fifty fish were not sexed. IDFG researchers performed biopsies on 39 adult sturgeon (15 females, 21 males, and 3 unknown). Males and females were at various stages of development for each sex. Sonic and radio tags were attached to six female and five male fish during this effort.

Adult White Sturgeon Telemetry

Forty-three white sturgeon with active transmitters were monitored for a total of 660.4 h of effort from September 1, 1995 to August 31, 1996 (Figures 4 and 5). From April 1 through August 31, 1996, 21 of the 43 tagged fish were monitored specifically for pre-spawn and spawning activities during 484.9 hours of telemetry effort. Locations, river discharges, and temperatures during the migration and spawning period are displayed for the 21 suspected spawners (Appendix C). One-hundred eighty-nine trips were made to five sections throughout the study area to monitor radio- and sonic-tagged sturgeon during the pre-spawn and spawning period in 1996. Twenty-six trips targeted the section from the

Table 1. Sampling effort and number of juvenile and adult white sturgeon caught by IDFG in the Kootenai River, January 1,1996 to August 31, 1996.

Gear type	Hours of effort	Number of juvenile sturgeon caught	Number of adult sturgeon caught	Juvenile CPUE (fish/h)	Adult CPUE (fish/h)
Gill net (2.5-7.6 cm mesh)	443	51	4	.12	.01
Rod & Reel[a]	87	1	6	.01	.07
Setlines[a]	1,656	4	44	.002	.03
TOTAL	**2,186 1,743[b]**	**56**	**54**	**.03**	**.03**

[a] Gear targeted at adult white sturgeon only.
[b] Effort targeting primarily adults.

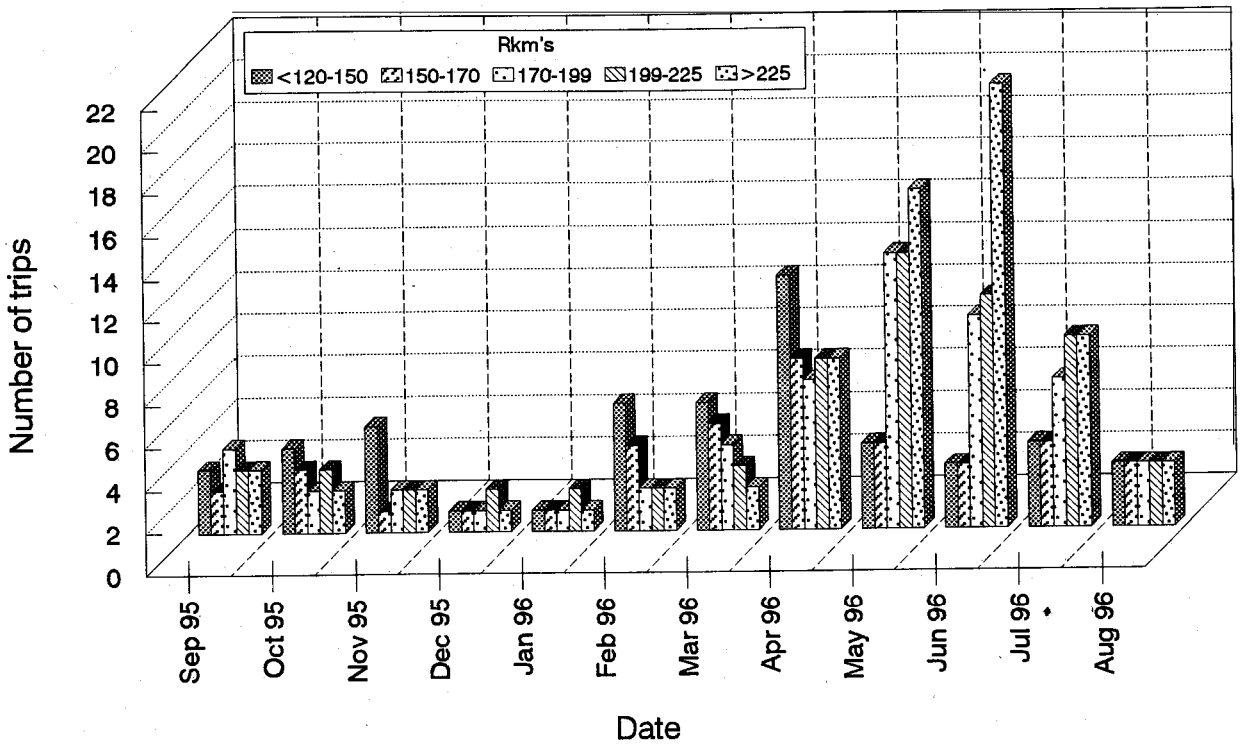


Figure 4. Telemetry effort by river kilometer section for the Kootenai River and Kootenay Lake, September 1, 1995 to August 31, 1996.

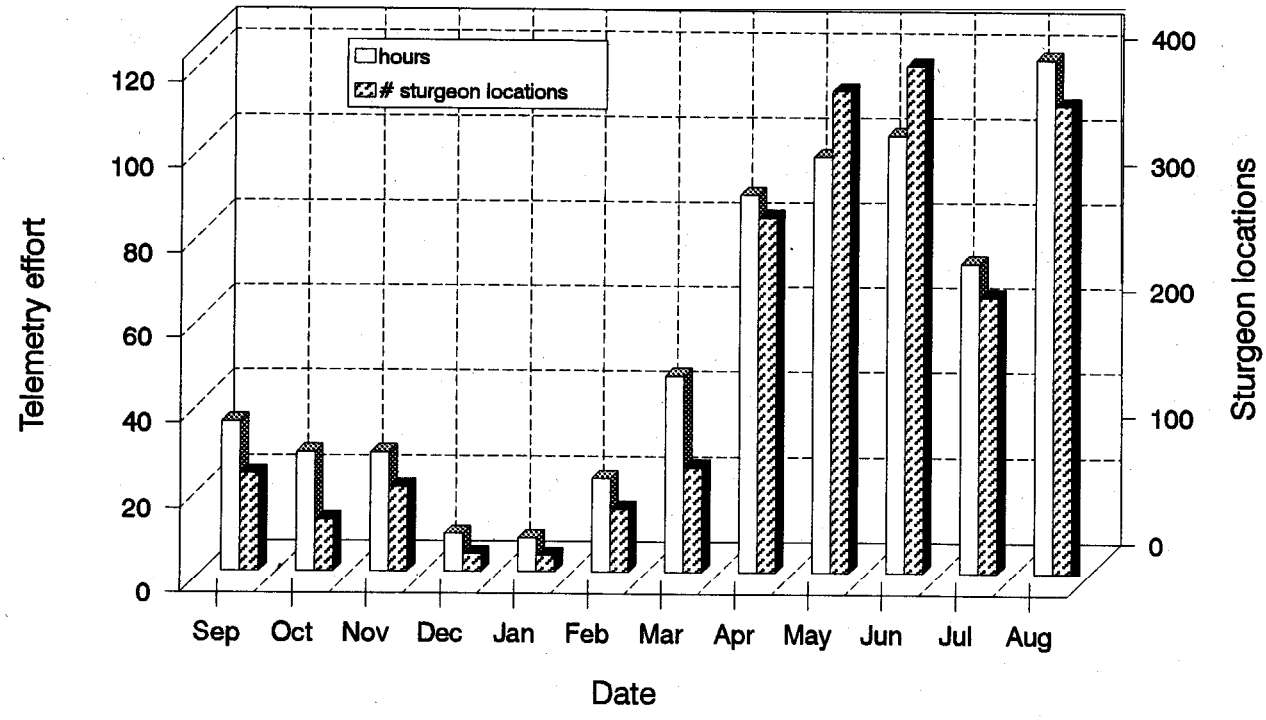


Figure 5. Telemetry effort (hours) and number of white sturgeon locations monthly from September 1, 1995 to August 31, 1996.

Kootenay Lake delta to Creston, 22 trips from Creston to Porthill, 40 trips from Porthill to Copeland, 44 trips from Copeland to Flemming Creek, and 57 trips from Flemming Creek to the confluence of the Moyie River (Figure 6).

Migration of Monitored Sturgeon in 1996

Seventeen adult males and 26 females carried transmitters in 1996 (Table 2). Six males (#'s 349, 417, 581, 621, 626, 2,057) and 13 females (#'s 348, 363, 403, 436, 438, 548, 555, 568, 619, 623, 625, 628, 629) remained in Kootenay Lake during the pre-spawn and spawning period. Of the above lake dwelling fish, two were tagged in 1991, one in 1992, two in 1993, six in 1994, and eight in 1995. Five fish (three males and two females) made brief movements out of the lake and into the lower river (rkm >122 <204). An additional four fish (one male and three females) went upriver as far as Flemming Creek (rkm 225). We tracked the remaining 15 fish (7 males and 8 females) to locations upstream of Flemming Creek. Most of these sturgeon migrated to spawning locations in the upper Kootenai River.

Sturgeon Tracked to Locations Upriver of Deep Creek

One male and four females were tracked to locations upriver of Deep Creek (rkm 240) (Tables 2 and 3, Appendix C). All were predicted spawners tagged in 1996. Three of the females and the male were tagged in the Rock Creek area (rkm 215.0-215.7). The last female was tagged near Ferry Island (rkm 205.0).

Male #732 moved almost 8 km downriver after tagging March 14. He moved upriver from Shorty's Island (rkm 233.3) by May 30 as flows were increasing. He reached rkm 243.8 on June 16 when flows had dropped from 1,397 m^3/sec (49,300 cfs) to 1,037 m^3/s (36,600 cfs). Water temperature on June 16 was 10.6°C (51°F). This male had dropped back downriver to rkm 218.2 by July 8.

Female #714 was tagged on March 5 near Ferry Island (rkm 205.0). She remained below Ferry Island until May 28 when she moved slightly upriver to rkm 210.5. Female #714 moved further upriver by June 7 to rkm 244.1, .4 km below Ambush Rock. Flows were over 1,133 m^3/s (40,000 cfs) and water temperature was 9.2°C (49°F). She was located downriver at rkm 160.2 by June 19, went upriver briefly between July 8 and July 16 to rkm's 184 to 207.8, but was located near Kootenay Lake on August 20 at rkm 129.5.

Female #'s 718, 723, and 730 were tagged at Rock Creek on March 5, 9, and 12, respectively. Female #718 remained downriver of Rock Creek until May 21 when she traveled upriver to rkm 234.8, reaching Ambush Rock by May 23 when flows were at 1,085 m^3/sec (38,300 cfs) and water temperatures 7.2°C (45°F). This female stayed upriver until

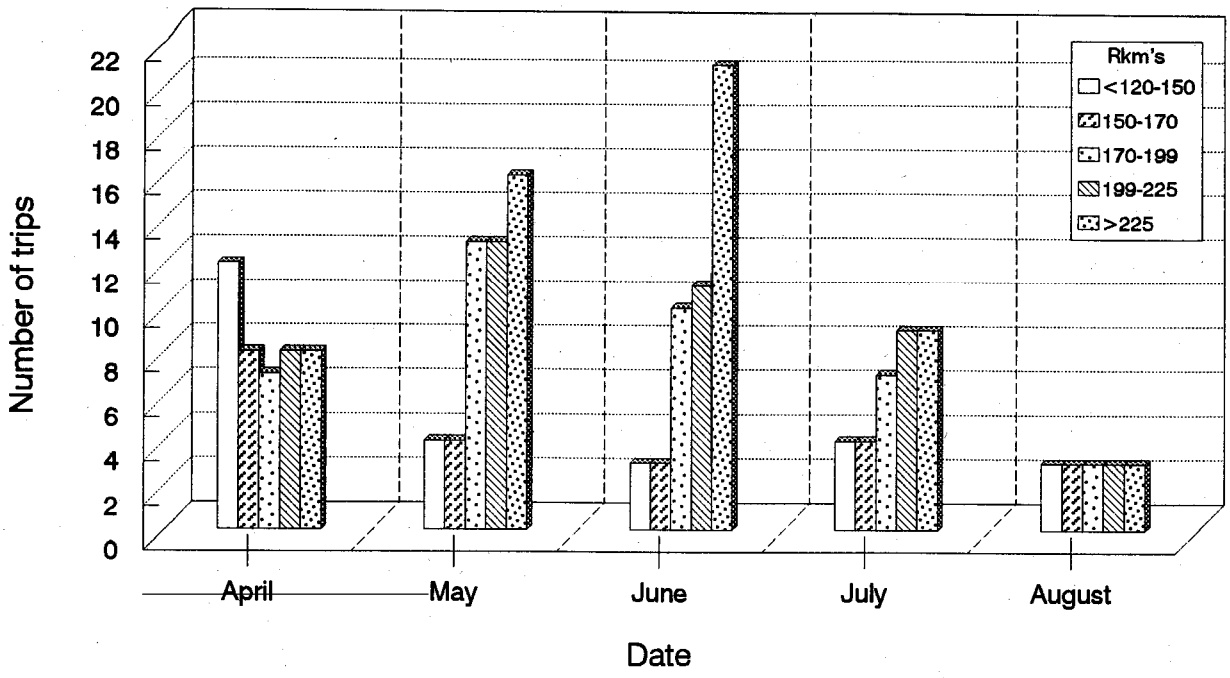


Figure 6. Telemetry effort (number of trips) by river kilometer section on the Kootenai River and Kootenay Lake for September 1, 1995 to August 31, 1996.

Table 2. Upriver locations of monitored white sturgeon that moved out of Kootenay Lake during the experimental flow test, April 1,1996 to August 31, 1996.

Fish #		Tagging Location (rkm)	Date Tagged	Highest rkm (Date)			Last Date Located Above rkm 225
Male	Female			>1225203	>2035225	>225	
	163[a]	215	4/26/94	-	213.5(6/10)°	-	-
	293[a]	83	8/6/94		b	239.5(6/14)	8/21
407[a]	-	215.6	3/6/96	-	-	238.4(6/13)	8/21
417[a]	-	17	8/16/94	c	-		--
445[a]	-	230.5	6/8/95		b	235.9(6/13)	7/16
	530[a]	118	2/12/94	146.3(8/5)	-		--
565[a]		193	3/19/94	133.8(8/14)	-		--
581 [a]		215	4/6/94	c	-		--
585[a]	-	203	4/18/94	139.8(5/7)	b	229.5(5/30)	6/1
620[a]		205	3/20/95	--	-		
-	682[a]	227.5	5/15/95	--		239.6(6/14)	8/31
	714[a]	205	3/5/96	--	b -	244.1(6/7)	6/12
-	715[a]	215.6	3/5/96	--	--	239.5(6/14)	6/17
	716[a]	215.8	3/5/96	--	--,	236.6(6/11)	6/14
-	718[a]	215.5	3/5/96	--	--	244.5(5/23)	6/10
720[a]		215.6	3/6/96	--	--	239(5/28)	6/24
722[a]		215.5	3/7/96	--	--	237(6/11)	6/13
	723[a]	215.7	3/9/96	--	--	245.4(6/8)	6/18
-	730[a]	215	3/12/96	--	--	240(6/10)	6/16
732[a]		215	3/14/96	--	--	243.8(6/16)	7/5
734[a]		215.6	3/18/96	--	--	239.1(6/14)	shed 238.5(6/24)
	348	203	4/19/94	--	--	--	
349		240.5	6/1/91	--	--	--	
	363	231	7/11/91	--	--	--	
	403 '	230.9	5/20/92	--	--	--	-
	436	207.8	4/27/93	--	--	--	-
-	438	120	6/23/93	--	--	--	
	548	216	3/2/94	--	--	--	
	555	206.5	3/11/94	--	--	--	-
-	560	204.9	3/18/94	--	205.7(6/20)	--	-
-	568	215.5	3/19/94	c	--	--	--
	619	205	3/20/95	c	--	--	--

Table 2. Continued.

date located			Fish #	Tagging	Date		Highest rkm (Date)	Last
Male	Female	location (rkm)	tagged	>122,<203	>203,<225	>225	above rkm 225	
621	–	185.5	5/9/95	[o]	-			
-	623	215.4	3/24/95			–	–	
624		215.4	3/24/95	143(6/11)	–	–	–	
	625	216.3	5/30/95		–			
626	–	215	3/29/95			–	–	
	628	215	3/29/95	[c]	–	–	-	
-	629	215	3/29/95				-	
-	636	205	4/4/95	169.3(8/5)	--		–	
637	–	205.3	4/4/95	–	–	–	--	
	649	205	4/12/95	–	201(6/3)			
2057		215	3/29/95	[c]	2058(6/7)			
n=6	n=16	Non-spawners (n=22)						
n=11	n=10	Spawners (n=21)						
n=17	n=26	combined (n=43)						

Suspected spawners in 1996.
These fish overwintered in this river section - all others were either tagged during 1996 or overwintered in the Kootenay Lake. These fish did not make any upriver movement out of Kootenay Lake in 1996.

Table 3. Fish tracked to sections of the Kootenai River, where white sturgeon eggs were spawned [a] back-calculated spawning date), within 24 hours preceeding spawning date.

Location	Egg spawn dates	Fish #	
		Males	Females
Upper Shorty's Island (rkm 231.6-233.4)	6/8	734 720	714
	6/9	722 715	716
	6/10	407 445	293
	6/12		
Myrtle Creek (rkm 233.5-234.7)	6/6	732 715	714 293
	6/7	734 445	730
	6/8	722	723
	6/9	407	716
	6/10	720	682
Wildlife Refuge (rkm 234.8-237.5)	6/9	732	714
	6/10	734	718
	6/11	722	723
	6/12	720	716
	6/13	715	682
	6/14	445	293
	6/15		
	6/16		
	6/18		
	6/19		
	6/20		
	6/21		
	6/22		
	6/24		
	6/25		
Deep Creek (rkm 237.6-240.5)	6/13	732 715	730 293
	6/14	734	723
	6/16	407	682

[a] This assumes that eggs were spawned in the same river reach where they were collected.

June 12 when she was located at rkm 218.0. Flows were dropping from a peak of 1,397 m3/sec (49,300 cfs) on June 5. She remained in this area until July 5, then moved 84.5 km downriver to Kootenay Lake within seven days. Female #723 remained near the Rock Creek area after tagging until June 5 when she was located at the mouth of Myrtle Creek (rkm 234.7). She traveled upriver as high as rkm 245.4 (upriver from Ambush Rock) by June 8 and remained above Myrtle Creek until June 18. Flows during this time varied from 986 to 1,397 m^3/sec (34,800 to 49,300 cfs), but were steadily dropping. Temperatures between June 5 and June 18 ranged from 9.1°C to 11.3°C (48°F to 52°F). Just two days later, she was located 50 km downriver (rkm 187.5). Female #730 moved upriver to lower Shorty's Island by June 4, reached as high as Deep Creek (rkm 240.0) by June 10, and was back downriver at rkm 182.0 by June 18, moving 51.9 km in just two days. No eggs were found above Deep Creek (rkm 240.0) in 1996.

Sturgeon Tracked Above rkm 225 But Below rkm 240

Six males (#'s 407, 445, 585, 720, 722, 734) and four females (#'s 293, 682, 715, 716) traveled to locations beyond Flemming Creek (rkm 225) but below Deep Creek (rkm 240.0) (Table 2, Appendix C). Four males and two females were tagged in 1996 at Rock Creek (rkm 215.4). Male #720 moved to upriver spawning areas (rkm 239.0) by May 28. Discharge on this date was 1,144 m^3/sec (40,400 cfs) and the water temperature was 8.4°C (47°F). From May 30 to June 24, this fish moved up and downriver between rkm 239.0 and rkm 230.0. He moved downriver to rkm 211.5 (Hops Farm) and remained till June 30, and was at rkm 188.6 (bend below Parker Creek) by July 5. The remaining three males (#'s 407, 722, 734) and two females (#'s 715, 716) moved to upriver spawning areas (rkm 236.6 to rkm 239.5) from June 11-14. Male #407 moved to rkm 238.4 by June 13 and back down to Shorty's Island by June 14 where he stayed the remainder of the spawning period. Male #722 moved up to the Kootenai River National Wildlife Refuge area (rkm 237.0) by June 11, back down to Shorty's Island briefly from June 12-13, and then downriver to Rock Creek (rkm 215.4), and eventually the lower river (rkm 126.5) by July 15. Male #734 moved up and downriver between rkm 239.1 (June 14) and rkm 230.0 between May 19 and June 14. Sometime around June 17 he shed his tag, which was later retrieved, at about rkm 238.9. Female #715 moved up to Shorty's Island by June 5 and reached her furthest upriver point (rkm 239.5) by June 14. She moved 18 km downriver to rkm 218.6 by June 18 and was at the lake by August 20. Female #716 was tracked to lower Shorty's Island (rkm 228.6) on May 28 and above the Refuge Hole (rkm 236.6) on June 11. She moved steadily downriver to rkm 218.0 by June 20 and the lower river (rkm 132.0) by July 16.

Male #445 was tagged at upper Shorty's Island (rkm 230.5) and female #682 at lower Shorty's Island (rkm 227.5) in 1995. Male #445 traveled between the Rock Creek area and Shorty's Island in 1995, overwintered at lower Shorty's Island, and moved up to rkm 235.9 by June 13 during the 1996 spawning period. He returned briefly to lower Shorty's Island between June 18 to July 16, then moved further downriver near the Turner Hill Hole (rkm 219.5). Female #682 spent 1995 near lower Shorty's Island and Upper Krausse Hole (rkm 227.5-207.8), moved upriver in 1996 to rkm 239.6 by June 14, and back downriver to lower Shorty's Island by June 20.

Male #585 was tagged at Ferry Island (rkm 203.0) and female #293 in Kootenay Lake at Crawford Bay (rkm 83.0) in 1994. Male #585 moved into the spawning areas from Ferry Island in May 1994, overwintered at Shorty's Island, moved back upriver from Myrtle Creek (rkm 235.5) in May 1995, was captured twice on set lines just below Copeland (rkm 199.4-197.3) in July 1995, and overwintered at lower Shorty'Island. In 1996, he moved up to rkm 229.5 by May 30, then briefly down to Fisher Creek in June, and finally to rkm 177.0 by July 16. Female #293 came upriver from the north end of Kootenay Lake late in 1995 and overwintered at Rock Creek (rkm 215.0) and Wiggley Bend (rkm 193.2). She was tracked upriver to rkm 239.5 on June 14, then downriver to lower Shorty's Island by June 20.

Fourteen adult white sturgeon were tracked into spawning areas on days that eggs were spawned (Table 3). This is discussed further in the section on Artificial Substrate Mat Sampling.

Sturgeon Tracked Above rkm 122 But Below rkm 225

Four fish were tracked to locations above Ferry Island (rkm 203.6) but below Flemming Creek (rkm 225) (Table 2, Appendix C). Two of these fish (females #163 and #649) overwintered in this section of the river. Female #163 may have moved upriver with spawners in 1995. She remained in the Trout Creek area (rkm 213.2), where she had overwintered, during the entire 1996 spawning period. Female #649 also moved into the spawning areas in 1995. She traveled as high upriver as Ferry Island (rkm 205.8) once in June 1996, but stayed below Parker Creek (rkm 190.1) most of the year. Female #560 remained where she had overwintered in the Ferry Island area (rkm 203.8) throughout the 1996 spawning period. This fish was tagged in 1994 and moved into the spawning areas that same year. Male #637 was tagged at Ferry Island in April 1995, moved to the spawning areas in May 1995, and down to the lake where he overwintered. In November 1995 he traveled upriver as high as rkm 201.0 in June 1996, but returned back downriver by August to stay near the East Channel juncture with the main Kootenai River (rkm 132.1).

Five fish, including three males (#'s 565, 620, 624) and two females (#'s 530, 636) moved into the lower river during the 1996 spawning period (Table 2, Appendix C). All but

one of these fish (#620) overwintered in the lake. Male #620 was tagged, but did not spawn in 1995. This fish overwintered just upriver from the East Channel break off (rkm 132.1) where it remained until August 5 when it was located in the lake. Female #530 and male #565 were both tagged in 1994 and were expected to spawn in 1996. Neither fish moved further in the river than rkm 146.3 (downriver from Creston) during the spawning period. Female #636 and male #624 were tagged and moved into the spawning areas in 1995. Both fish made brief trips to the lower river in 1996, moving back to Kootenay Lake afterwards.

Fixed-Receiver Telemetry Results

The fixed-receiver (rkm 245.6) gave us mixed results due to the high flows and resulting turbidity in the river this year. There was an unusually high level of background noise that interfered with the receiver's ability to consistently differentiate noise from actual radio frequencies. However, it was able to detect the probable movements of four fish past the three-element Yagi antenna at the fixed-receiver station. Detections occurred on days when there was not a high degree of background interference. The upriver movements were supported by previous and later locations of the same radio frequencies from the boats. Because these probable movements cannot be verified 100%, they were not discussed in previous sections on upriver movements of spawning fish. They are mentioned here because they suggest the potential for movement of spawning fish upriver from Bonners Ferry (rkm 245.8), which we previously have been unable to detect. The fixed-receiver locations at rkm 245.6 represent the furthest upriver location for all four fish.

Female #'s 714 and 723 went past the station at rkm 245.6 on June 7 from 1116 to 1120 and June 8 from 1059 to 1303, respectively. Female #714 was located by boat earlier June 7 (0850) at rkm 244.1 and #723 was located by boat at 0935 at rkm 245.4 on June 8. Male #732 was detected at the station between 1634 June 14 and 2100 June 15. This fish had been previously located by boat at rkm 241.0 June 14 at 0910 and was later located June 16 at rkm 243.8 at 1325. Female #715 was detected by boat as,high as rkm 239.5 on June 14 at 0930, went past the fixed-receiver from 0213 to 0227 June 15, and was located June 16 at 1405 back downriver at rkm 236.6.

Aerial Telemetry Results

Twelve sturgeon were located from the airplane in 1.5 hours of flying between Bonners Ferry (rkm 245.8) and the Kootenay Lake delta (rkm 119.0) on June 12. All 12 locations were close (within approximately .2 rkm's) to previous and later locations of the same fish by boat. Some fish were located only by flying up and downriver several times and the detection distance was short (approximately .5 river kilometers). We were able to detect fish in the shallow water of the Kootenay Lake delta, but not in the deeper portions.

The addition of a loop antenna on the wing on July 9 improved signal strength and detection distance. We detected all fish previously located by boats. Detection distance was still too short to avoid flying past some fish as the receiver went through the cycle of possible signals.

Artificial Substrate Mat Sampling

We collected 2,495 mat samples in the Kootenai River during the 1996 flow spawning season (Table 4). A mat sample is equal to the time a mat is in the river without being pulled and checked. Average set time for all mats was 25.5 hours and 52 hours for mats containing eggs. The total sampling time for egg mats was 106,787 hours to collect 348 eggs and one hatched eggshell in four river sections. We expended 43,877 hours of mat sampling effort between rkm 228-240.5 and 62,910 hours of effort above rkm 240.5 (Appendix D). Egg collection catch effort was 0.0033 eggs/h. Egg mat effort decreased steadily during June, however number of eggs collected increased.

Depth of artificial substrate mats ranged from 1 to 25.9 m (3 to 85 ft) for all mats. Depth ranged from 6.4 to 17.4 m (21 to 57 ft) and averaged 13 m (43 ft) for mats that collected eggs. Temperature at egg collection sites ranged from 9.5-13.5°C (49-56°F) with an average of 11.7°C (53°F). Surface velocities at 30 of 44 egg collection sites ranged from .08 to .38 m/s (.25 to 1.25 ft/s) and averaged .17 m/s (.55 ft/s). Velocities near the river substrate at 31 of the 44 egg collection sites ranged from .09 to .38 m/s (.3 to 1.25 ft/s) and averaged .16 m/s (.51 ft/s) (Appendices E and F).

The 348 sturgeon eggs and 1 hatched-out egg shell were collected from 44 individual substrate mats within four different river sections during 1996. The majority (262 eggs) were collected in the Kootenai River National Wildlife Refuge section from rkm 234.8 to 237.5. Fifty-five eggs were collected in the upper Shorty's Island section (rkm 231.6 to 233.4). Twenty-seven eggs were collected in the Myrtle Creek section (rkm 233.5 to 234.7). Five eggs were collected in the Deep Creek section (rkm 237.6 to 240.5). No eggs were collected in the middle or lower Shorty's Island sections (rkm 228.0 to 231.5) or above the Deep Creek section (>rkm 237.5) (Table 4, Appendices E and G).

The four largest spawning events based on our sampling and back-calculation to egg/spawn date took place: June 8 (29 eggs), June 10 (53 eggs), June 12 (33 eggs), and June 18 (50 eggs) (Appendix H). Flows on these collection dates were dropping slightly each day from 1,113 to 892 m^3/s (39,300 to 31,500 cfs). Other mat samples yielded from 1 to 20 eggs each (Figure 7, Appendices H and I).

Two hundred fifty-six (74%) of the 348 white sturgeon eggs were viable. Stages of egg development and date of fertilization were estimated. Development ranged from stage 12 to 27, with 62% of the eggs at stage 21 or earlier (Appendix J). Back-calculation of viable eggs indicated white sturgeon spawned during a minimum of 18 days in 1996.

Table 4. Location (rkm), depth (m), effort and white sturgeon egg catch by artificial substrate mats, Kootenai River, Idaho, 1996.

Geographical description	River location (rkm)	Number of mat samples°	Average depth (m)	Total sample hours[a]	Number white sturgeon eggs
Lower Shorty's Island	228.0-229.5	'135	40	5,684	0
Middle Shorty's Island	229:6-231.5	29	34	909	0
Upper' Shorty's Island	231.6-, 233.4	237	34	10,058	55
Myrtle Creek	233.5-234.7	172	36	5,605	27
Refuge	234.8-237.5	417	37	18,166	262
Deep Creek	237.6-240.5	64	33	3,455	5
Hatchery	240.6-243.9	65	27	4,672	0
Ambush Rock	244.0-244.6	210	46	8,173	0
US 95	244.7-246.6	1043	17	44,199	0
Upper Pump Station	246.7-247.7	123	12	5,866	0
All sections	**228.0-247.7**	**2,495**	**26**	**106,787**	**349[b]**

a Sampling effort for mats that were stuck and not retrieved after 10 days were not included in the total sampling effort.
b One of these eggs was a hatched out white sturgeon egg shell.
c One mat sample is equal to the time a mat is in the river before it is pulled and checked.

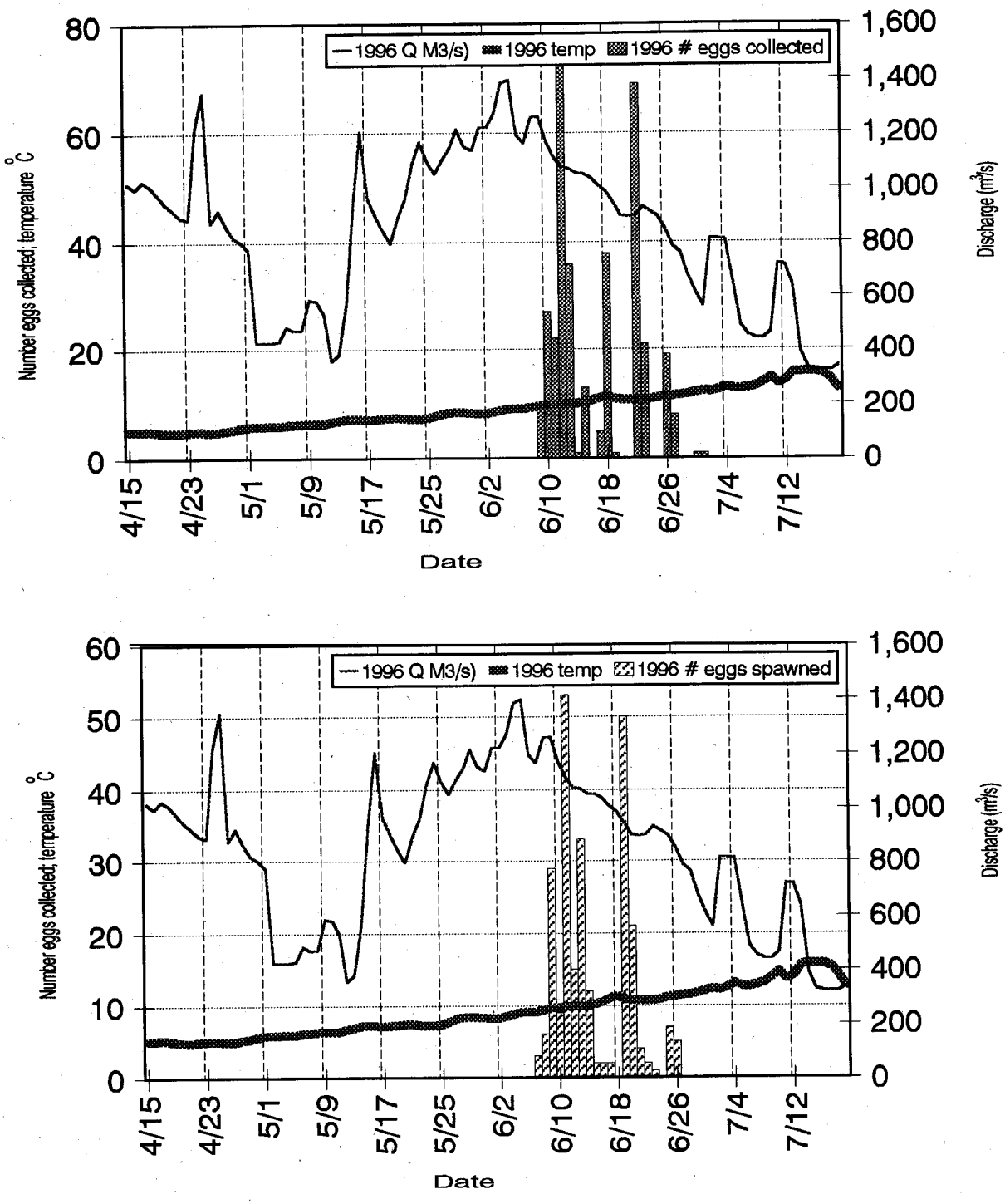


Figure 7. Top figure is collection date, number of eggs (n=349, including 1 hatched shell), temperature (^{0}C) and flow (m^3/s) on the Kootenai River at Bonners Ferry, Idaho during 1996. Bottom figure is spawn date, number of eggs (n=256), temperature (^{0}C) and flow (m^3/s).

Spawning was nearly continuous from June 6 through June 25 (Figure 7, Appendices H, I, and J). Although a large percentage of eggs were older than 72 hours, most eggs were captured soon after spawning events. Fifty-one percent of the eggs were less than two days old, 14% were 48 to 72 hours old, 36% were greater than 72 hours old. The oldest egg was estimated at 228 hours old, or about 9.5 days. We compared the average stage for sturgeon eggs collected in 1996 to those collected in 1994 and 1995 (Marcuson et al. 1995, Paragamian et al. 1996) using ANOVA and found the average stage was significantly older ($P = 0.0001$) than those collected in 1994 and 1995, average of stages 19, 16, and 15, respectively. Further testing with Fisher's LSD indicated eggs collected in 1996 were significantly older than 1995 ($P = 0.0001$) and 1994 ($P = 0.0208$).

Analysis of Egg Locations

The Kolmogorov-Smirnov test was used three times to examine the distribution of eggs during the 1994 through 1996 collections (Appendix G). We found significant differences in the distribution of eggs between all years ($P=0.0001$), eggs were further upstream in 1995 than 1994, and further upstream in 1996 than 1994 and 1995. We used the Kruskal-Wallace one-way nonparametric test to detect any statistical differences in the water velocities in the locations where eggs were collected during the three spawning years (Appendix F). This test was not significant ($P=0.776$) indicating there was no detectable difference in velocities.

Juvenile White Sturgeon Sampling

A total of 56 juvenile white sturgeon were captured by IDFG. Between July 6, 1996 and August 31, 1996, 443 hours of sampling effort was directed at collecting 51 juvenile white sturgeon (<120 cm TL, <115 cm FL) with gill nets (Table 1). An additional five more juveniles were caught while adult sampling. Forty-five were hatchery fish released in 1992 and 1994 and 11 were wild fish. Nineteen fin ray samples were taken for age verification.

Lengths of these juveniles ranged from 48 to 105 cm FL (Tables 5 and 6, Appendix K). Three fish were captured twice, five of the juveniles were captured during adult sampling and one additional sturgeon was captured by KTOI. CPUE for juveniles captured with gill nets was .12 fish/h. CPUE for juveniles captured during adult angling and set line gear was .01 and .002 fish/h respectively (Table 1). The additional juvenile sturgeon captured by KTOI but was not included in the CPUE estimate.

Forty-nine (88%) of the 56 small sturgeon (<120 cm TL, <115 cm FL) captured by IDFG were recaptures (45 hatchery and 4 wild) (Tables 5 and 6). Three of the 49 recaptures were actually small adults (based on age) originally marked in 1980 and 1982. One of the 49 recaptures was a wild juvenile from brood year 1991, originally tagged in

Table 5. Length, age, and brood year of wild juvenile white sturgeon that fit the length definition of juvenile sturgeon captured by IDFG, KTOI, and BCMOE in the Kootenai River, Idaho, August 1, 1995 to August 31, 1996.

Fish #	Date of capture #1	Length at capture #1 FLITL (cm)	Age	Date of capture #2	Length at capture #2 FLITL (cm)	Age	Brood year
3264	7/25/96	53/63	ND				
3265	8/1/96	61/71	5				1991
3251	3/6/96	86/99	ND				
3260	7/8/96	48/56	5				1991
3261	7/13/96	55/64	5				1991
3267[a]	5/17/96	103/118	ND				
3012	7/16/94	41/43	3	7/13/96	50/55	5	1991

[a] Captured by KTOI and not included in CPUE estimate.

Table 6. Length, age, and brood year of small adult white sturgeon that fit the length definition of juvenile sturgeon captured by IDFG, KTOI, and BCMOE in the Kootenai River, Idaho, August 1, 1995 to August 31, 1996.

Fish #	Date of capture #1	Length at capture #1 FL/TL (cm)	Age	Date of capture #2	Length at capture #2 FL/TL (cm)	Age	Date of capture #3	Length at Capture #3 FL/TL (cm)	Age	Date of Capture #4	Length at capture #4 FL/TL (cm)	Age	Brood year
3259	7/3/96	101/115	18										1978
1189	8/4/82	-/88	2	3/13/96	98/103	16							1980
594	6/10/80	-/75	7	6/3/82	-/80	9	6/28/94	90/107	21	3/18/96	97/114	23	1973
3254	3/13/96	105/118	12										1984
1034	4/25/80	-/50	**6**	7/6/96	93/104	22							1974

1994. The remaining 45 of the 49 recaptured juveniles were hatchery reared and released sturgeon. Three of the 45 hatchery juveniles were captured two times. Eighteen of the hatchery recaptures were from brood year 1992, stocked in 1994, 26 were from brood year 1991, stocked in 1992; and I was from brood year 1990, stocked in 1992. Two of the eight wild unmarked juveniles were small adults (based on age), three were not aged, and three were wild juveniles from brood year 1991.

Juvenile sturgeon were caught at Ferry Island (rkm 205), Rock Creek (rkm 215), Flemming Creek (rkm 225), and Shorty's Island (rkm 227-229) in water ranging from 8.5 to 20.7 m deep (28 to 68 ft). Wild and hatchery juveniles were caught together in similar locations.

Juvenile White Sturgeon Telemetry

Seventeen of 19 juvenile sturgeon reared at the KTOI hatchery had active transmitters in 1996. These fish were released in the fall of 1994, and were tracked from August 1, 1995 to September 30, 1996 (Marcuson et al. 1995, Paragamian et al. 1996). All fish were either released below Bonners Ferry or had moved into the river below town by late October 1994. One juvenile moved to the lower river (rkm 183.5) by early August, one moved downriver to the lake in 1996, and one stayed in Kootenay Lake. The remaining 14 stayed in the river above rkm 195 (Appendix L).

Age and Growth of Adult White Sturgeon

Length measurements of adult sturgeon captured between August 1, 1995 and August 31, 1996 ranged from 121 to 235 cm TL (48.4 to 94 in) and 105 to 201 cm FL (42 to 88.4 in) (Appendix M). Thirty-three of the 35 fin rays taken from adult and small adult sturgeon were useful for age analysis. An additional four fish were aged during previous years and recaptured in 1996. Ages of these 37 adult sturgeon ranged from 12 to 34 years (Appendix N). These adults were all from 1984 or prior year classes.

Growth rates of adult sturgeon captured between 1978 and 1982 averaged 3.4 cm TL (1.4 in) per year (SD=6.3) (Marcuson et at. 1995). Over the eight-year period from 1989 to 1996, 857 adult fish were caught. Fish were identified with Floy tags, PIT tags, or both. Growth rates calculated for sturgeon captured during 1996 were calculated from 169 recaptures with known fork lengths and 167 recaptures with known total lengths. Growth rates averaged 1.17 cm/year FL (.5 in) and 1.96 cm/year TL (.8 in) (SD=5.3 for FL and 5.5 for TL). Time intervals for measurements ranged from 26 days to 9 years. The maximum measurable annual growth was 31.9 cm FL (12.8 in) and 29.8 cm TL (11.9 in).

Twenty-seven of 1,206 adult fish tagged during white sturgeon studies from 1978 through 1982 and 1989 through 1996 were recaptured more than once. Eleven were caught three times, six were caught four times, four were caught five times, three were caught six times, two were caught seven times, and one fish has been captured eight times. Growth in total length for these fish averaged 2.9 cm (1.1 in) per year (SD=1.2). Intervals between multiple captures ranged from 2,610 to 5,813 days. Calculated growth (TL) ranged from 0.7 to 5.5 cm (0.3 to 2.2 in) per year. These fish should have had ample time between capture and recaptures to compensate for any influence of the fish's behavior due to the stress of handling and marking.

Age and Growth of Juvenile White Sturgeon

Lengths of juvenile white sturgeon captured between August 1, 1995 and August 31, 1996, ranged from 48 to 105 cm fork length (18.9 to 41.3 in) (Table 5 and 6, Appendix K). Ages of five of the 12 wild juvenile sturgeon (<120 cm TL, <115 cm FL) captured in 1996 ranged from 12 to 23 years, placing them into year classes between 1973 and 1984 (Appendices M and N). Three of the 12 wild juveniles were not aged. The remaining four wild juveniles were from the 1991 year class.

Five of the nine larger wild juveniles (as defined by length) were aged as adults ranging from 12 to 23 years old (Table 6). These small adults were placed in the adult category for age analysis. Two of these fish were captured at least twice since 1980, and one was captured four times.

Four of the remaining seven wild juvenile sturgeon were age 5, from the 1991 year class (Table 5). The only wild juvenile sturgeon captured by KTOI was not aged because a fin ray was not collected.

Fin ray sections from 11 hatchery juveniles were used for verification of accuracy in aging procedures. Of the 11 hatchery juveniles, one was age 6 from the 1990 year class, seven were age 5 from the 1991 year class, and five were age 4 from the 1992 year class (Appendix N). Annuli counts from all fin rays corresponded with actual ages of the hatchery sturgeon.

Growth rates were calculated from lengths of 69 juvenile white sturgeon that were captured more than once. Average growth per year was 4.71 cm FL (1.9 in) (SD=6.9) and 6.2 cm TL (2.5 in) (SD=7.9). Growth rates for nine small adults that were in the juvenile length category were 2.2 cm/year FL (.9 in) (SD=1.4) and 2.4 cm/year TL (1.0 in) (SD=1.4).

White Sturgeon Population Estimates

Population estimates of white sturgeon of two class intervals and three groups (>120 cm FL adults, <120 cm FL wild juveniles, and hatchery juvenile sturgeon) were computed from 15 years of mark and recapture data. We calculated an estimated population of 1,469 adult sturgeon (95% C.I.=740-2,197) in Kootenay Lake and the Kootenai River (downstream of Bonners Ferry) for 1995. This adult estimate is based on the capture of 1,151 sturgeon and the recapture of 250 fish. Annual survival (S) was estimated at 79% (95% C.I.= 62-96%).

We calculated an estimate of 87 wild juvenile white sturgeon (C.I. could not be calculated because of the small sample size) in Kootenay Lake and the Kootenai River (downstream of Bonners Ferry) for 1995. This estimate is based on the capture of 344 wild juvenile sturgeon and the recapture of 45 during the 15 study years. Annual survival (S) of wild juvenile sturgeon was estimated at 90% (C.I. could not be calculated because of the small sample size). We were unable to calculate an estimate of juvenile hatchery sturgeon numbers nor estimate annual survival because of the short time interval and low sample size. However, we did record the capture of 68 hatchery sturgeon and the recapture of 8 since 1993. Also, we will update our computer program each year by inputting captures and recaptures of sturgeon from each category to continue providing population estimates.

Larval Sturgeon and Burbot Samplina

A total of 167 subsurface meter net tows was completed in the Kootenai River from April 3 through August 1, 1996. Seventy-one percent of the tows occurred between rkm 227 and rkm 238, 26% were between rkm 146 and 191, while 3% were between rkm 146 and Kootenay Lake. Each collection sampled about 2,234 m^3 of water. We captured 34 larval fish primarily *Catostomus sp.* and Cyprinidae but none were white sturgeon or burbot. However, as many as five white sturgeon egg shells were found. Four egg shells were found between rkm 232.7 and 236.2, while one was collected between rkm 128 and rkm 132.

We sampled Kootenay Lake bi-weekly with 49 pairs of meter net tows (total of 98) March 20 through August 7. Each tow sampled about 2,442 m^3 (86,200 ft^2)of lake water. A total of 22 larval fish were caught by meter net of which 20 were caught during daylight and two at night. Four larval fish were caught at site one, 11 at site two, 5 at site three, and 2 at site four. With the exception of one larval kokanee caught in April, the remaining larval fish were caught in May. However, no larval white sturgeon or burbot were captured. Mid-water trawling in the South Arm of Kootenay Lake and beam trawls in the river and lake failed to capture any larval white sturgeon or burbot (Robert Lindsay, personal communication, BCMOE; Steve Dalbey, MDFWP).

No juvenile fish were taken with 40 passive D-ring samples in the Kootenai River. Collections were from June 21 through August 1, 1996 and from rkm 217.2 to 237, 87% were between rkm 227 and 237, while the remainder were between rkm 217.2 and 226.9. Average sampling period was 2.77 h and 1,306 m^3 (46,100 ft^2) of water for each sample. We also failed to capture any juvenile or larval sturgeon or burbot with 55 shrimp trawls. Shrimp trawling effort took place from August 12 through September 4. Trawls were taken from rkm 175.3 to 231.7; 34% from rkm 227 to 231.7, 51% from rkm 191 to 226.9, and 15% from rkm 175.3 to 190.9. Trawls averaged 14.7 min in duration.

Laboratory Egg Development and Sand Test

This experiment was initiated but all eggs soon perished. Simultaneous to the loss of eggs in our experiment was the loss of the remaining 80,000 eggs in the KTOI Hatchery, the entire production for 1996.

White Sturgeon Spawning Summary - 1996

Monitoring Kootenai River white sturgeon spawning during 1996 indicated spawning occurred in June but the extent of larval survival is unknown. Spawning took place under operation of Libby Dam for flood control and unregulated local inflow (stream flow from below Libby Dam). Scheduled test flows were delayed until July because of an estimated 126% snow pack and an exceptionally wet spring. Natural runoff events of over 1,130 m^3/s (40,000 cfs) provided a discharge at Bonners Ferry that exceeded the scheduled test conditions. As a result, operation of Libby Dam was for flood control and prevention of spill.

Adult white sturgeon migration to spawning areas during 1996 occurred in late May during a rising hydrograph (Figure 3). This migration pattern was similar to that of previous study years. Discharge was near 1,077 m^3/s (38,000 cfs) and water temperature averaged about 8°C (46°F) and both were rising. Discharge at Bonners Ferry peaked at about 1,397 m^3/s (49,300 cfs) on June 5, 1996. A total of 348 eggs (and one egg shell) were collected during the flow events. The first white sturgeon eggs were collected on June 8 and collections continued through June 30. Staging of eggs and back dating to spawning indicated there were at least 18 spawning episodes spanning from June 6 through June 25. Discharge on June 6 was 1,196 m^3/s (42,200 cfs) and decreased steadily to 893 m^3/s (31,500 cfs) by June 25. Temperature during these spawning events was 9.1°C (48°F) on June 6 and rose slowly to 11.2°C (52°F) by June 26. Discharge was gradually reduced to 440 m^3/s (15,500 cfs) by July 9 to initiate the first of two test flows with a rising hydrograph (Figure 3). These test flows were also to incorporate a temperature increase by manipulating the location of water withdrawn from Lake Koocanusa. The reduction in discharge occurred during sturgeon spawning; by July 1 discharge was reduced to 561.1

m^3/s (19,800 cfs) and temperature was 12.4°C (54°F). Discharge at Libby Dam was immediately increased, and by July 2 was up to 813 m^3/s (28,700 cfs) at a temperature of about 12.6°C (55°F) at Bonners Ferry. On July 3 discharge was decreased to 440 m^3/s (15,500 cfs) and temperature was 13.9°C (57°F). Discharge at Bonners Ferry was increased on July 10 and peaked at 719.8 m^3/s (25,600 cfs) at 14.2°C (58°F). No spawning is known to have occurred during these July test flows, nor was there any evidence of any movement of adult fish that was in direct response to changes in the discharge pattern.

DISCUSSION

Peak discharge in 1996 was nearly equivalent to the 1991 and 1974 discharges at Bonners Ferry. These two years produced the two primary cohorts of white sturgeon since Libby Dam was completed in 1972. "We did not expect white sturgeon to continue spawning in the reach in the vicinity of Shorty's Island (rkm 227 to 237) where substrate is primarily sand and the current is slow (<0.75 m/s). At discharges in excess of 1,135 m3/s (40,000 cfs), we expected sturgeon to spawn in the vicinity of Bonners Ferry in habitat comprised of clean cobbles and gravel and swifter water (>2 m/s). Although our fixed-location receiver recorded five white sturgeon in the reach from Ambush Rock upstream (rkm 245-246), we did not capture any sturgeon eggs above rkm 239. Thirteen white sturgeon eggs were captured in this reach in 1991 under discharge conditions similar to 1996, and three were collected in 1993 when discharge conditions were only 568 m^3/s (20,000 cfs).

The issue of habitat selection for white sturgeon spawning remains unresolved because of the mixed findings from 1991 through 1996. Spawning site selection of Kootenai River white sturgeon in 1994, 1995, and 1996 suggests spawning habitat needs of this population may be different than other populations in the Columbia Basin (Appendix F). We once believed higher discharges in 1974 and 1991 enabled sturgeon to spawn in the most suitable' habitat upstream of rkm 245 and resulted in a higher number of recruits; however, data from 1994 to 1996 do not support the necessity of swift water and clean cobbles for spawning. Despite the high water in 1996, the main body of spawners were between rkm 230 and rkm 238. Although we have documented sturgeon spawning in what is thought to be the best habitat by Columbia River standards (Parsley and Beckman 1993), spawning in the slower current and sand substrate may be normal for Kootenai River white sturgeon, although at this time we do not understand how this may relate to egg and larval survival.

The total volume of discharge in the Kootenai River may be more critical to egg and larval survival than micro-habitat selection. For example, we found the average egg stage for sturgeon eggs collected in 1996 was significantly older than those collected in 1994 and 1995. Discharge and the total volume of water from May through June in 1996 was higher than 1994 and 1995 (Appendix H). We also note this hypothesis is untested, and egg staging is subject to human error. Many of the eggs collected in 1996 were within a day

of hatching, and several egg cases from hatched larval sturgeon were collected on egg mats and in meter net tows. Warmer water may speed sturgeon egg development to a maximum temperature of 20°C (68°F) (Beer 1981). However, water warmed slower in 1996 than in 1994, and overall temperatures were usually lower than 1994 and 1995 (Appendix I). Thus the presence of older eggs in 1996 does not appear to be related to water temperature. But it is unknown how important the total volume of historic discharges were to the survival of white sturgeon eggs and larvae. Also, the factor of the elevation of Kootenay Lake is an additional variable; a discussion follows in this report. The uncertainties of discharge volume, peak discharge, temperature, and Kootenay Lake elevation as factors to larval sturgeon survival places even more importance on our need to develop a reliable means of measuring larval sturgeon abundance and survival.

Our combined population estimate of wild adult and juvenile white sturgeon was substantially higher than estimates by Partridge (1983) and Apperson and Anders (1991) because our estimate included fish captured in Kootenay Lake rather than the river alone. The combined estimate of wild adult and juvenile white sturgeon in 1995 was 1,555, Partridge's (1983) estimate was 1,194 sturgeon (C.I.= 907-1,503), while Apperson and Anders' (1991) estimate was 880 fish (C.1.= 638-1,211). The addition of Kootenay Lake in our estimate was important because a substantial number of white sturgeon inhabit the lake, as confirmed by the hundreds of sturgeon captured in the Lake by the BCMOE and recorded in this report and others (Paragamian et al. 1995, Lindsay 1997). Also, by using fish in the lake and river we reduced bias created by the movement of marked fish out of the river to the lake or unmarked fish moving into the river from the lake. Although our estimate of adult sturgeon is higher than earlier studies, the population is still imperiled, as evidenced by an estimate of 87 wild juveniles. Our estimates also differed from past estimates in that we used the Seber-Jolly method (Ricker 1975). The Seber-Jolly estimate was based on 15 years of mark and recaptures, we used several different class intervals to estimate the number of adult and juvenile fish, our method (Seber-Jolly) also took into account the distribution of effort in the river and lake and had a survival and recruitment component. Conversely, the previous estimates used the Schnabel method and were based on a much shorter mark and recapture period (one to three years). Also, since 1994 we have used small mesh gill nets to capture smaller sturgeon that were not captured in earlier studies.

The total value of the 1996 test flow may have been compromised by the capture of broodstock by the KTOI during the study. Over 50 adult sturgeon were captured and examined for suitability as broodstock for the hatchery while the flow study was taking place. A total of 11 sturgeon were removed from the river and brought into the hatchery, 9 males and 2 females. Similar activities may have compromised the test flows in 1995 (Paragamian et al. 1996). In addition, in 1996 one female in the vicinity of suitable spawning habitat (Ambush Rock) was removed from the river and brought into the hatchery. We believe the continued capture of broodstock during the flow test is counterproductive and prohibits a valid evaluation of test flows for white sturgeon. If culture of sturgeon is to continue, a broodstock collection protocol, including the collection of fish prior to spawning should be developed and followed.

Elevation of Kootenay Lake may have some influence on the location of white sturgeon spawning. Elevation of Kootenay Lake has a profound effect on stage and velocities of the Kootenai River as far upstream as Bonners Ferry. The historic elevation of Kootenay Lake prior to Libby Dam averaged 534.87 m (1,754.4 ft), while after 1972 it has averaged 532.68 m (1,747.2 ft). White sturgeon eggs collected during 1994,1995, and 1996 were found within the same reach of river (rkm 228 to rkm 238). However, there appeared to be a general trend for more eggs to be collected further upstream within this reach in 1996 vs. the previous two years. Review of the water level records for Kootenay Lake elevations during the beginning of the white sturgeon spawning season indicated 1996 was highest at 534.11 m (1,751.88 ft), 1995 was next at 533.47 m (1,749.78 ft), while 1994 was lowest at 532.34 m (1,746.09 ft). Apparently white sturgeon were also spawning in locations of similar velocities between years. Kootenay Lake elevations in 1991, when eggs were collected over cobble substrate, was lower than 1996, reaching a maximum of 533.58 m (1,750.15 ft), but was higher than other post-dam years. For reference, 1993 reached a maximum of 532.27 m (1,745.84 ft). The Kootenai River White Sturgeon Recovery Team has requested that elevation of Kootenay Lake be raised to about 535 m (1,754.8 ft) for the 1997 flow test to further study this possible factor to spawning location.

The origin of unmarked juvenile sturgeon is still in question. Although they appear to be wild based on marking conventions, it has been repeatedly suggested that they are not wild but they escaped from the hatchery. Many fin rays from white sturgeon of known hatchery origin captured in the Kootenai River exhibited what appears to be a stress check followed by reduced growth to the next annulus. The check always occurred in the year the fish were known to be released. In 1995 we examined six fish captured in 1994 and 1995 that we believe were wild white sturgeon from the 1991 year class. These fish did not exhibit what we believe is a stress check. A larger sample of wild fish and review by an unbiased expert is necessary to test this observation before we can conclude that this is a reliable indicator of hatchery vs. wild origin.

The principle objective of this investigation is to identify the minimum discharge neccessary to produce sufficient recruitment of a white sturgeon year class. Three years of study has resulted in a substantial number of eggs collected but sturgeon recruitment remains unknown. Three years of regulated discharge from Libby Dam produced higher flows (1974, 1991, and 1996) than anticipated because of major rain events in June. The test flows of 1994 and 1995 were compromises for the higher flows and 1996 flows were near unregulated conditions but the results to recruitment still remain unknown. Thus, we recommend a test flow for 1997 that is as similar in volume and discharge to that of 1996 without impacting agricultural interest. The test should begin when river temperature approaches 9°C (48°F) and should be in increments of 57 m^3/s (2,000 cfs) per day to a minimum of 1,130 m^3/s (40,000 cfs) at Bonners Ferry. We also recommend no load following. Our continued concern is not to adversely impact lands adjacent to the river. However, recent disclosures from the USACE indicates discharges below 1,425 m^3/s (50,000 cfs) cause no serious jeopardy to these adjacent lands. Evidence suggests that the higher flows of 1991 encouraged white sturgeon to spawn over the cleaner gravels

above rkm 246 and this resulted in successful hatching. It is also advisable to test the hypothesis: Kootenay Lake elevation significantly effects microhabitat spawning parameters of depth, substrate, and velocity.

RECOMMENDATIONS

1. On or about 15 April (when water temperature is about 9°C (48°F) maintain a minimum spring run-off of 425 m^3/s (15,000 cfs).

2. Provide between 708 m^3/s (25,000cfs) and 765 m^3/s (27,000 cfs) from Libby Dam for 42 days when water temperatures approach 10°C to 12°C (50°F to 54°F).

3. Provide discharge of 311.5 m^3/s (11,000 cfs) for 30 additional days in July to early August. We believe it is needed to maintain sufficient habitat for rearing of larval sturgeon.

4. Eliminate load following.

5. Acoustic Doppler Current Profiles of white sturgeon spawning sites and non spawning habitat should be prepared to help identify sturgeon spawning habitat characteristics.

'ACKNOWLEDGMENTS

We would like to thank the following bio-aides for their assistance with data collection during the 1996 field season: Chris Lewandowski, Genny Hoyle, Kara Hilwig, Mark Gilliland, Jake Venard. Thank you to Kim Apperson, Ned Horner, and Al Van Vooren of IDFG and Ken Lepla of Idaho Power Company and Rick Westerhof of BPA for reviewing the manuscript. Funding for this work was provided by Bonneville Power Administration.

LITERATURE CITED

Apperson, K., And P. J. Anders. 1991. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for ,Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

Bonde, T.H., and R.M. Bush. 1975. Kootenai River water quality investigations, Libby Dam preimpoundment study 1967 - 1972. U.S. Army Corps of Engineers.

Beer, K.E. 1981. Embryonic and larval development of white sturgeon (Acipenser transmontanus). Master's Thesis, University of California, Davis, California. 93 pp.

Fredricks, J. and L. Fleck. 1996. Estimating Abundance of Larval and Advanced YOY Sturgeon and Burbot in the Kootenai River and Kootenay Lake. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

Lindsay, Robert. 1997. Final Report for Kootenai Lake white sturgeon investigations April, 1995 to March 1996. British Columbia Ministry of Environment. Final Report. Project IDFG 94-H93 OW-03-5, Nelson, British Columbia, Canada.

Marcuson, P.E., G. Kruse-Malle, and V.D. Wakkinen. 1995. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

McCabe, G.T., and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Fish and Game 76(4):248-250.

Northcote, T.C. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report Number 2, Ann Arbor, Michigan.

Paragamian, V., G. Kruse, and V.D. Wakkinen. 1995. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

Paragamian, V., G. Kruse, and V.D. Wakkinen. 1996. Kootenai River white sturgeon investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

Paragamian, V., and V. Whitman. In Press. Kootenai River Fisheries Investigation: Stock Status of Burbot. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65, Portland, Oregon.

Partridge, F. 1983. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Job Completion Report. Project F-73-R=5, Subproject IV, Study IV, Boise.

Parsley, M.J. and L.G. Beckman. 1994. White sturgeon spawning and rearing habitat in the lower Columbia River. North American Journal of Fisheries Management 14:812-827.

Pith:), John. 1995. An evaluation of walleye and sauger populations and associated fisheries in Pools 11 and 18 of the Upper Mississippi River. Iowa Department of Natural Resources. Federal Aid to Fish Restoration Annual Performance Report Mississippi River Investigations, Project FF-144-R-3.

Ricker, W.E. 1975. Computations and interpretation of biological statistics of fish populations. Bulletin 191, Fisheries Research Board of Canada, Ottawa.

APPENDICES

Appendix A. Top table is number of adult sturgeon caught, recaptures and effort for agencies involved in white sturgeon sampling from August 1, 1995 to August 31, 1996, Kootenai River and Kootenay Lake, Idaho and British Columbia, Canada. Bottom table is number of juvenile sturgeon caught, recaptures and effort for agencies involved in white sturgeon sampling from August 1, 1995 to August 13, 1996, Kootenai River and Kootenay Lake, Idaho and British Columbia, Canada.

Adult captures

Agency name	Number of fish caught	CPUE (fish/h)	Number of recaptures (%)
Idaho Fish and Game	54	.03[a]	22 (41)
Kootenai Tribe of Idaho	53	.04	26 (49)
BC Ministry of Environment	118	ND	43 (41)
Total	**225**	**.04[b]**	**91 (40)**

[a] This CPUE does not include the 4 adult sturgeon caught during juvenile sampling. .

[b] This CPUE does not include BCMOE effort.

Juvenile captures

Agency name	Number of fish caught	CPUE (fish/h)	Number of recaptures (%)
Idaho Fish and Game	56	.12[a]	49 (88)
Kootenai Tribe of Idaho	1	ND[b]	0
Total	57	.12	49 (88)

[a] This CPUE does not include the 5 juvenile sturgeon captured during adult sampling.

[b] This fish was captured during adult sampling.

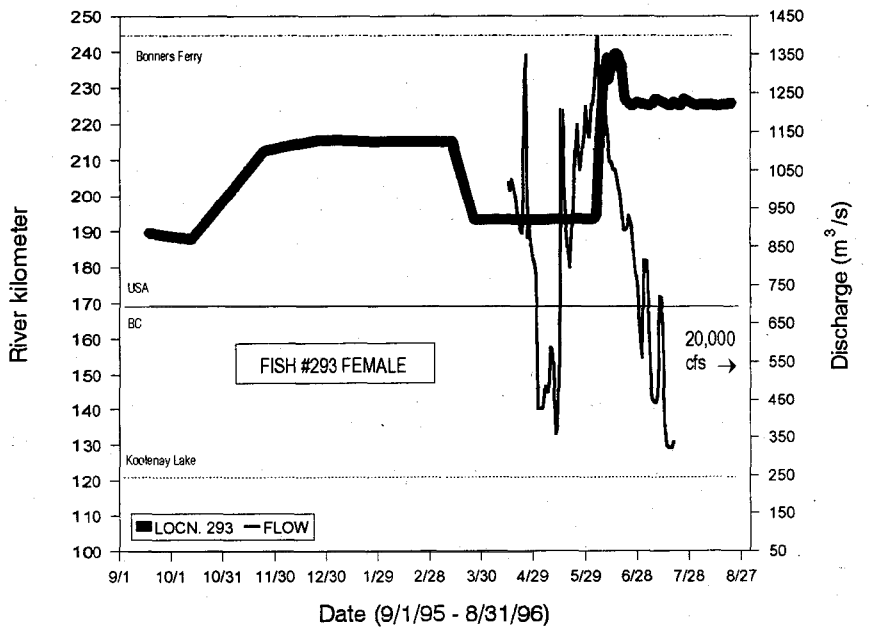
Appendix B. Sexual development of white sturgeon sampled by IDFG, KTOI, and BCMOE in the Kootenai River, Idaho, 1989 through 1995.

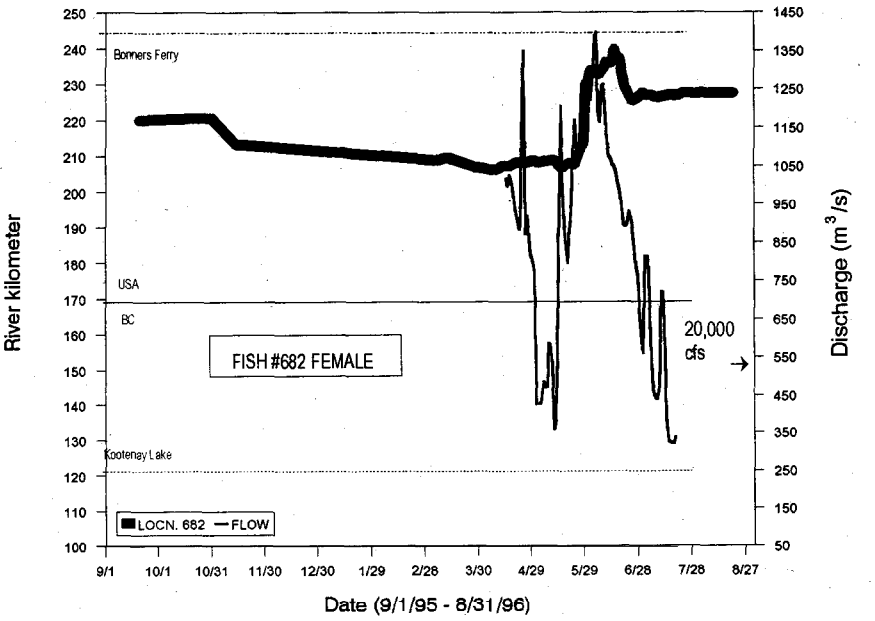
Categories of sexual development		Percent (number) of sample by year							
Category/Sex	Description of development	1989	1990	1991	1992	1993	1994	1995'	1996'
0/Unknown	Gonad undifferentiated or not seen	3 (58)	1 (15)	6 (3)	2 (1)	0	24 (14)	0	45 (67)
1/Female	Previtellogenic: No visual signs of vitellogenesis; eggs present but have average diameter <0.5 mm	14 (25)	12 (13)	8 (4)	12 (5)	0	**5** (3)	11 (3)	5 (7)
2/Female	Early vitellogenic: Eggs are cream to gray; average diameter 0.6-2.1 mm	7 (12)	7 (8)	**4** (2)	2 (1)	5 (1)	2 (1)	0	4 (6)
3/Female	Late vitellogenic: Eggs are pigmented and attached to ovarian tissue; average diameter 2.2-2.9 mm	6 (10)	5 (5)	8 (4)	9 (4)	53 (10)	2 (1)	0	2 (3)
4/Female	Ripe: Eggs are fully pigmented and detached from ovarian issue; average diameter 3.0-3.4 mm	2 (3)	5 (5)	4 (2)	9 (4)	11 (2)	14 (8)	25 (7)	5 (7)
5/Female	Spent: Gonads are flaccid and contain some residual fully pigmented eggs	3 (5)	1 (1)	2 (1)	0	5 (1)	0	3.5 (1)	0
6/Female	Previtellogenic with attritic oocytes: Eggs present but have an average diameter <0.5 mm; dark pigmented tissue present that may be reabsorbed eggs	2 (3)	0	0	0	0	0	0	1 (2)
R/Female	Reabsorbing eggs		0		2 (1)	0	0	0	1 (1)
7/Male	Non-reproductive: Testes with translucent smokey pigmentation	3 (6)	27 (30)	29 (15)	26 (11)	0	19 (11)	36 (10)	13 (20)
8/Male	Reproductive: Testes white with folds and lobes	32 (58)	28 (31)	18 (9)	16 (7)	21 (4)	35 (20)	21 (6)	20 (31)
9/Male	Ripe: Milt flowing; large white lobular testes	0	3 (3)	14 (7)	21 (9)	5 (1)	0	0	2 (3)
S/Male	Spent: Testes flaccid; some residue of milt		0	8 (4)	0	0	0	3.5 (1)	2 (3)

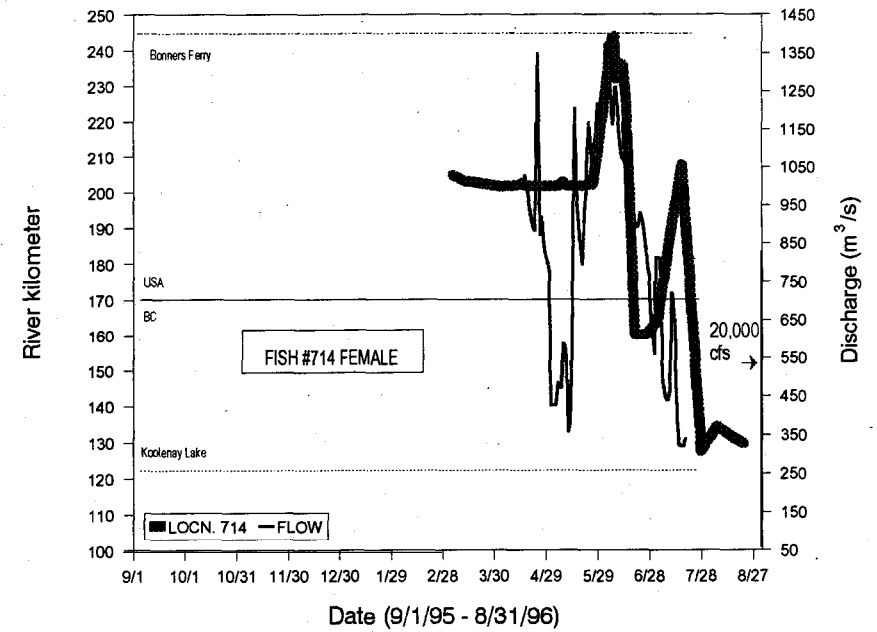
[a] Surgeries done by IDFG and KTOI were carried out on fish that externally appeared to be candidates for spawning.

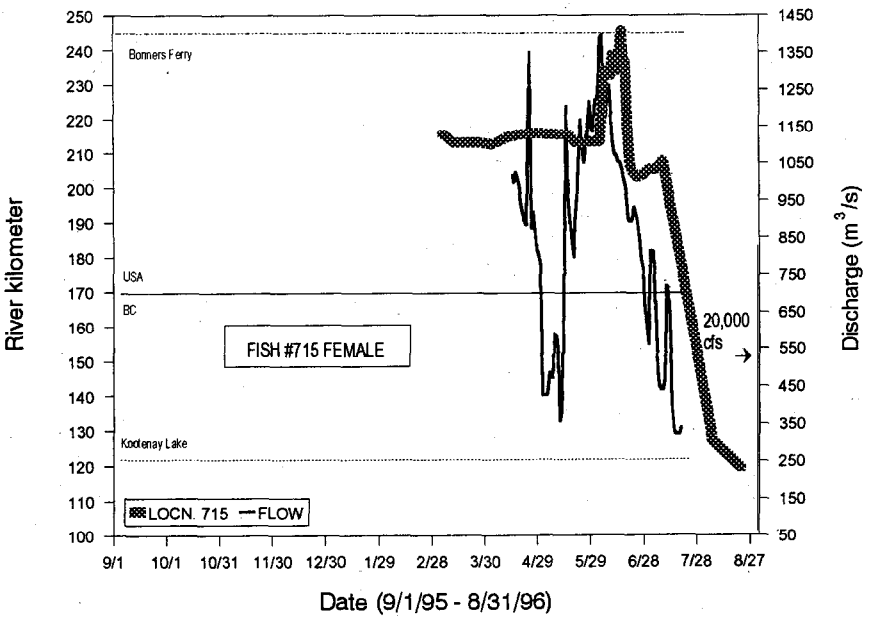
Surgeries done by BCMOE and those done during previous years were more randomly distributed among fish >130 cm.

[b] Fish that we did not perform surgery on were placed in the unknown category.

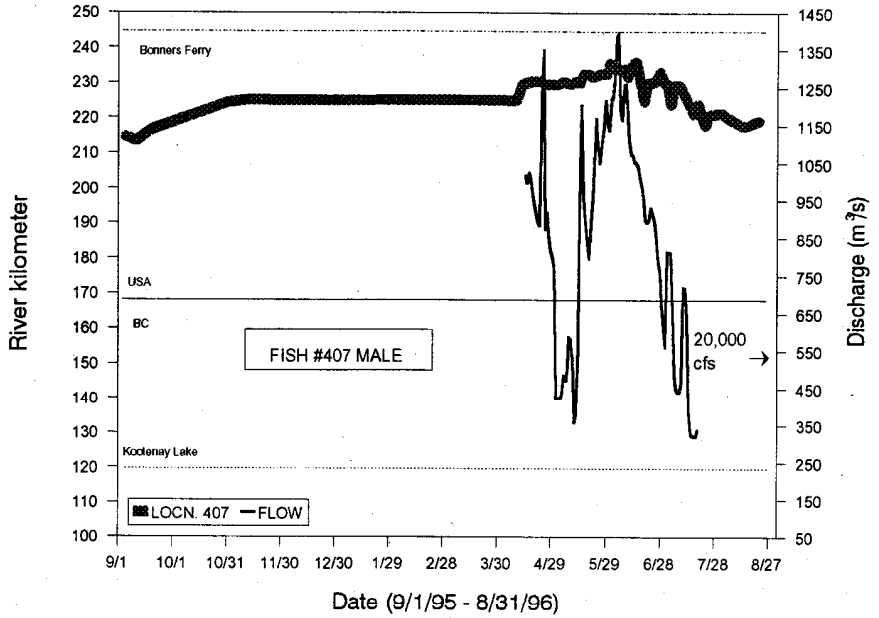


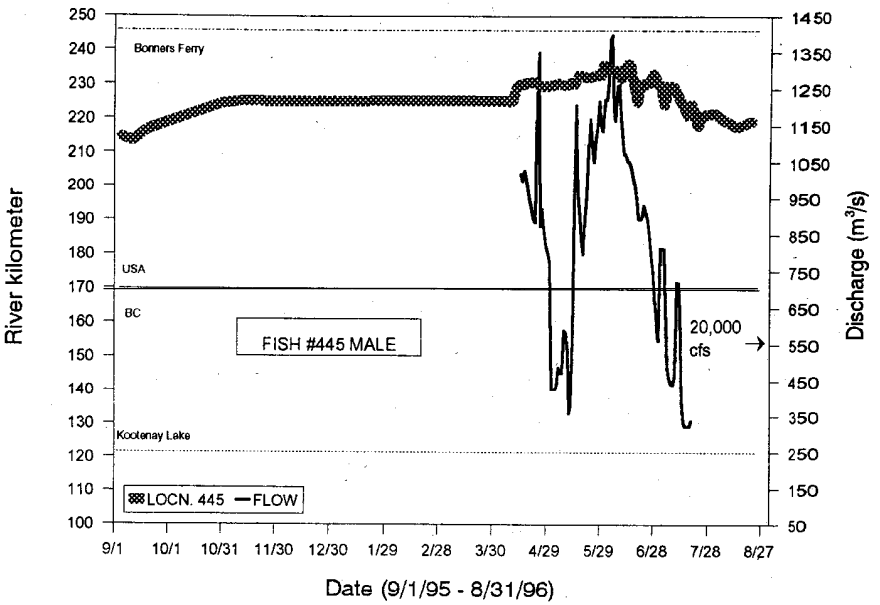


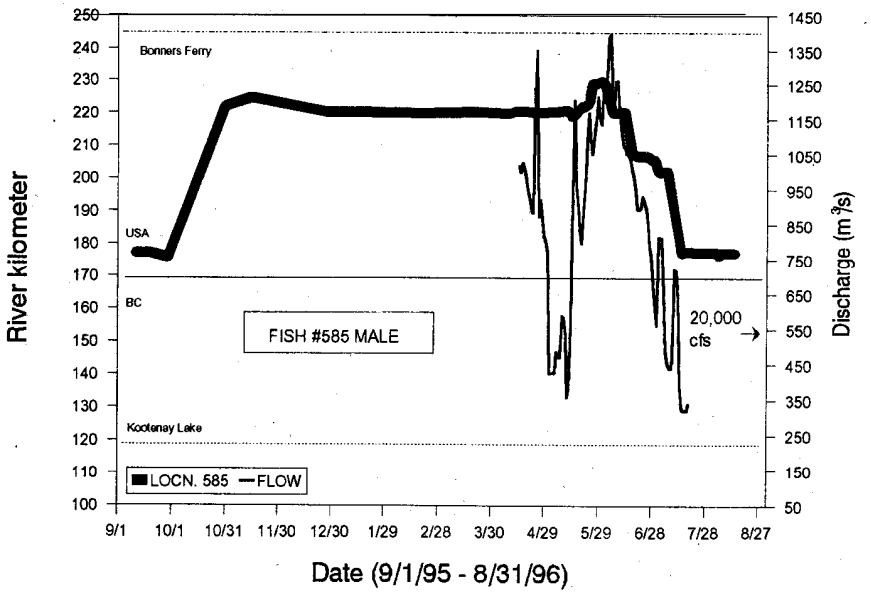


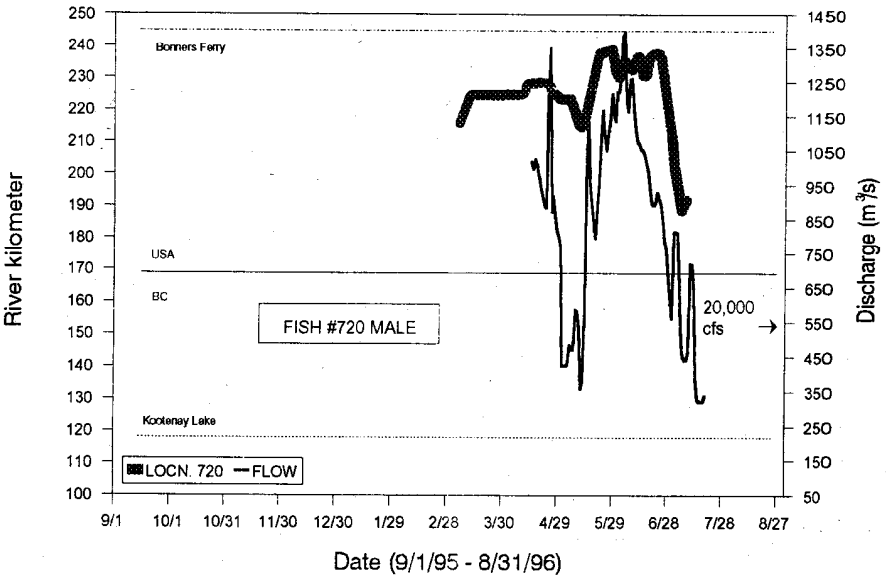


Appendix C. Description of the movement of white sturgeon tagged with radio and sonic transmitters and tracked for movement during spawning in the Kootenai River in 1996.

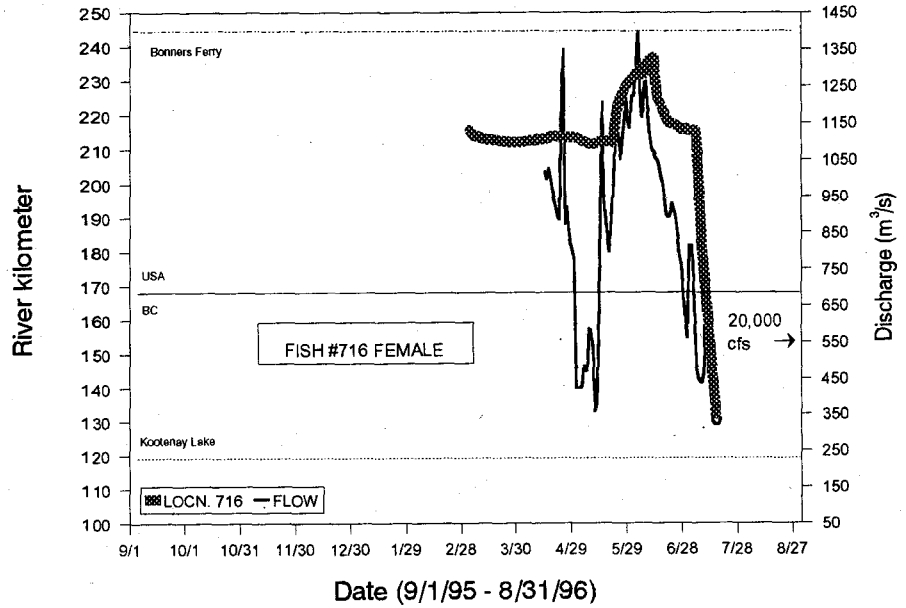


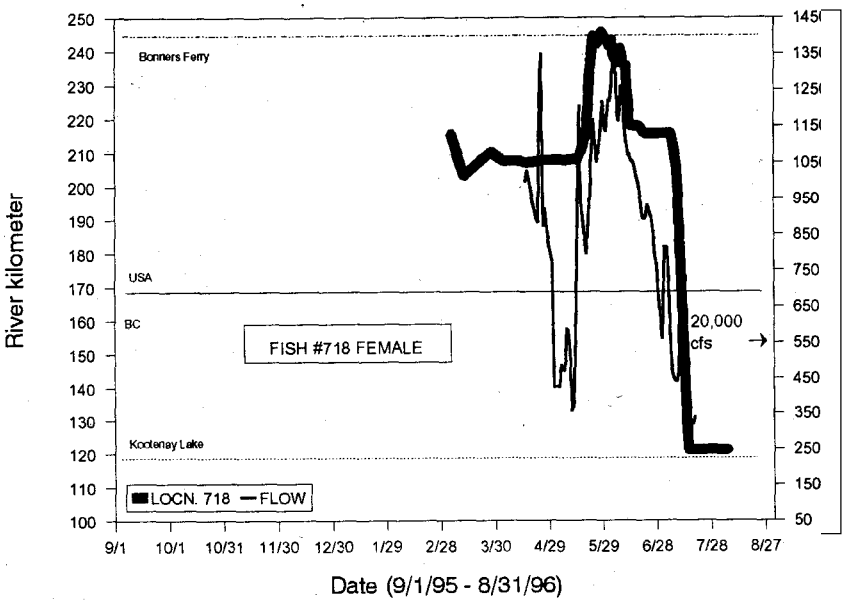


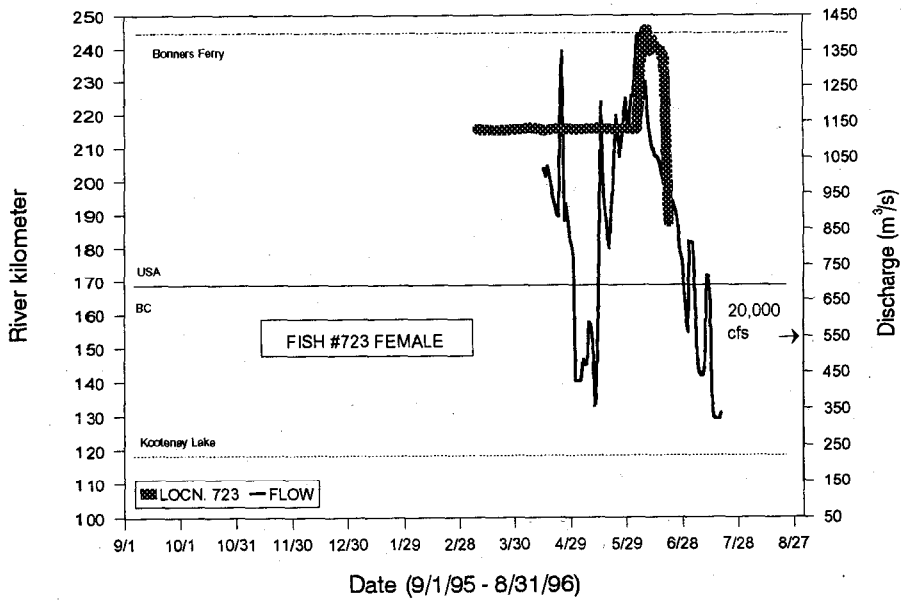


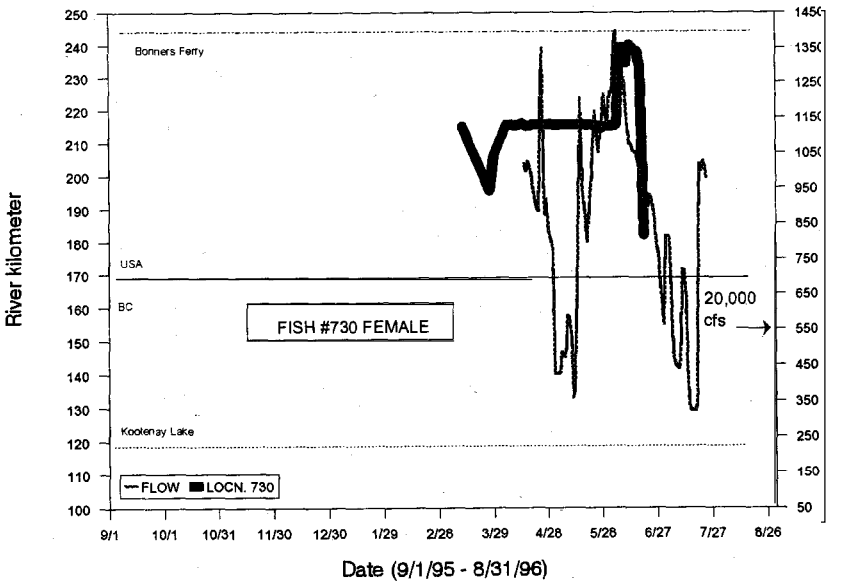


Appendix C. Continued.

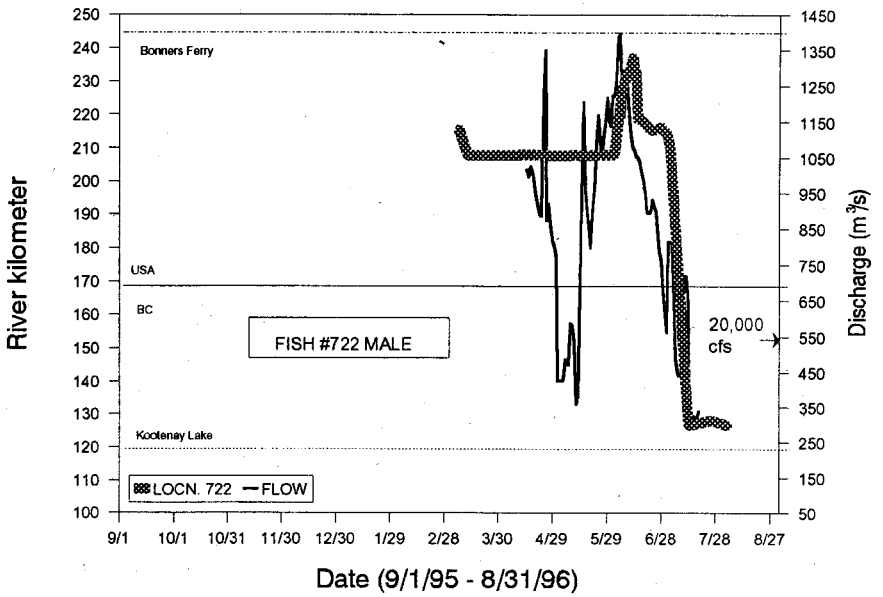


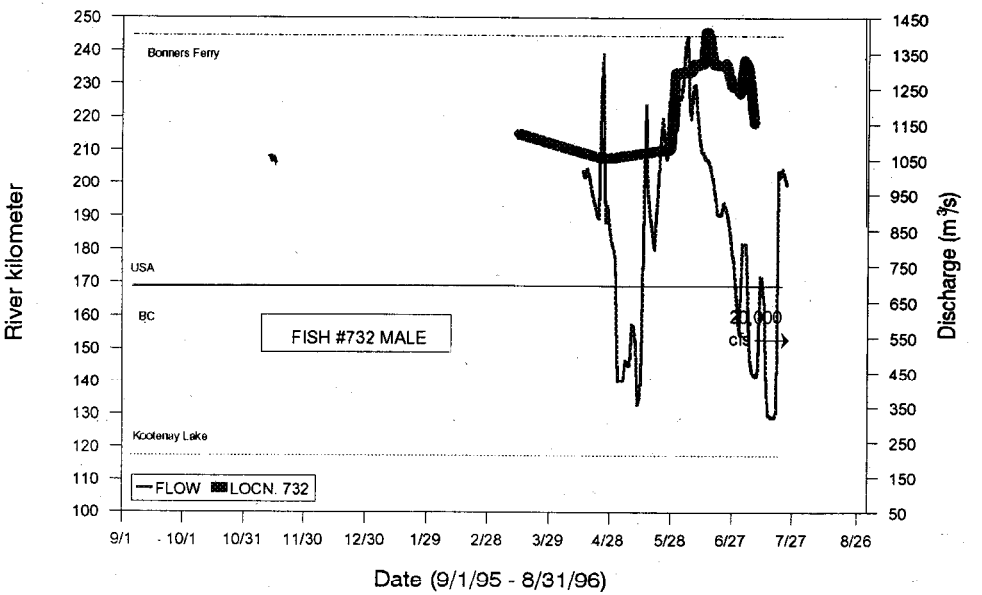


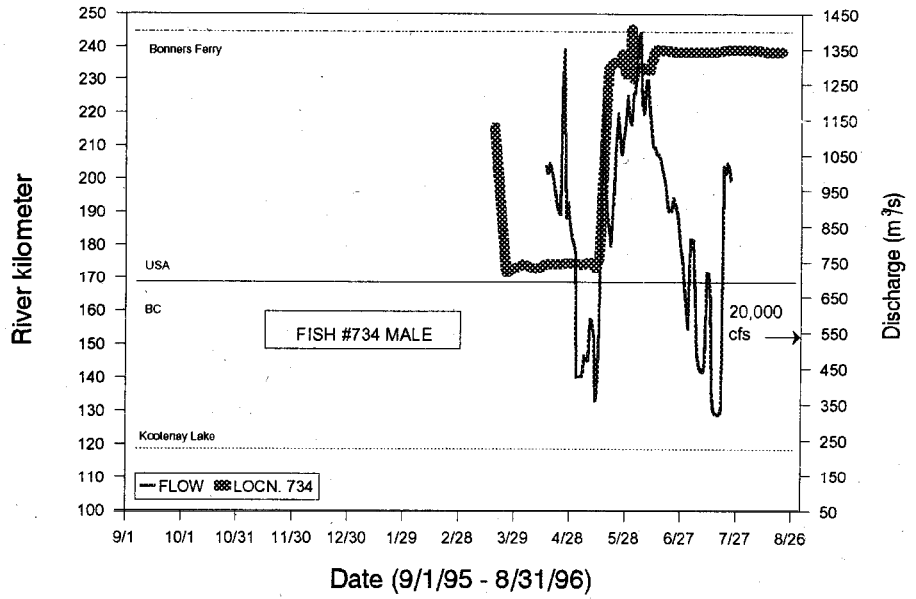




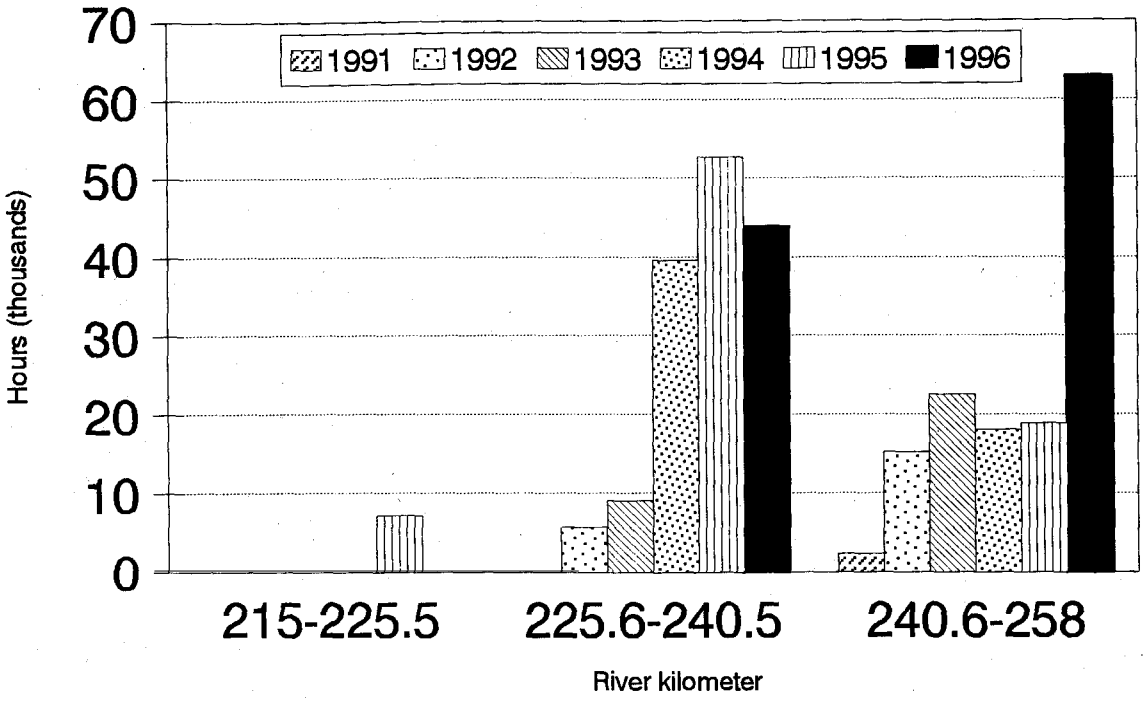
Appendix C. Continued.







Appendix C. Continued.

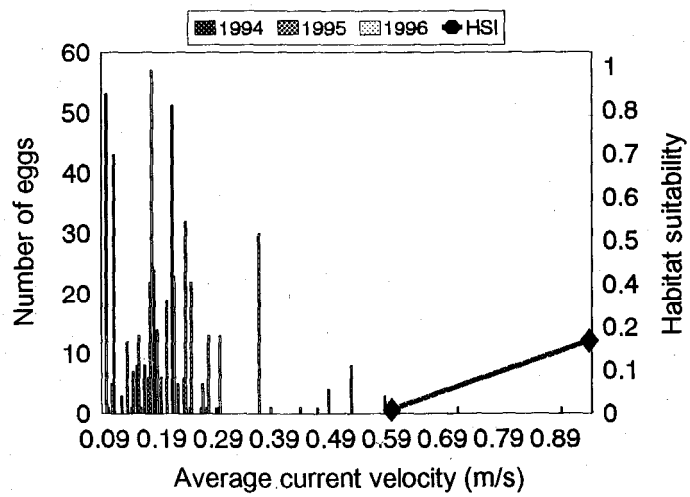


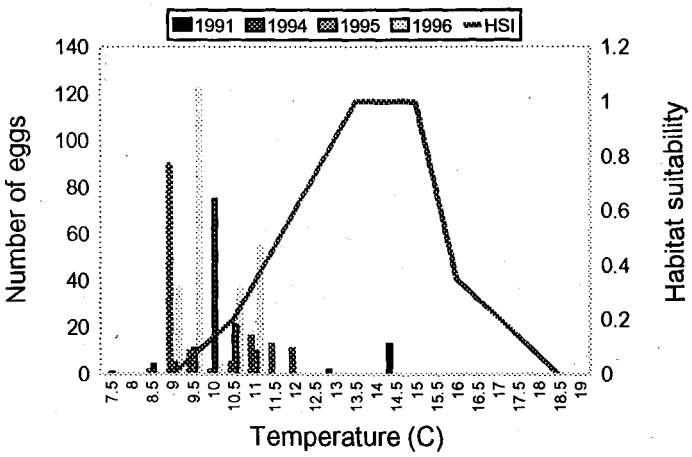
Appendix D. Egg mat sampling effort by river section in the Kootenai River, Bonners Ferry, Idaho, 1991-1996.

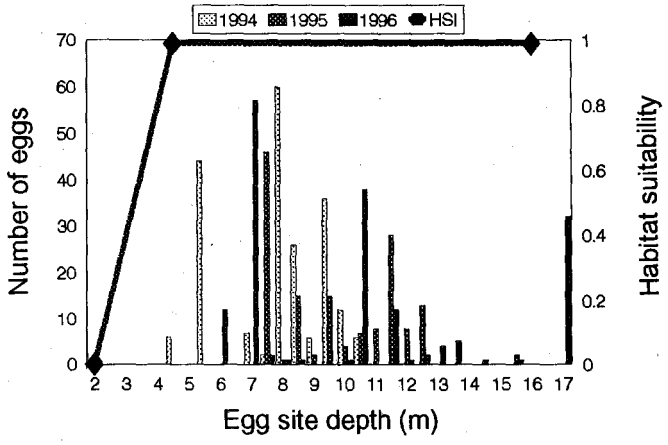
Appendix E. River location (rkm), number of eggs, depth (m), temperature (°C) and velocity at sites (m/s) where white sturgeon eggs were collected, Kootenai River, Idaho, 1996.

River section (rkm)	# Eggs	# Mats w/eggs	Depth range (m)	Mean depth (m)	Mean temp. (°C)	.2[b] Velocity (m/s)	8[c] Velocity (m/s)	Mean velocity (m/s)
237.6-240.5	5	1	ND	ND	13	0.18	0.18	0.18
234.8-237.5	262[a]	28	6.4-17	12	11.7	0.24	0.20	0.20
233.5-234.7	27	9	12-13	13	11.1	0.27	0.18	0.23
231.6-233.4	55	6	12-14	13	11.2	0.3	0.24	0.27
All locations	349[a]	44	8-19	13	11.7	0.17	0.16	0.16

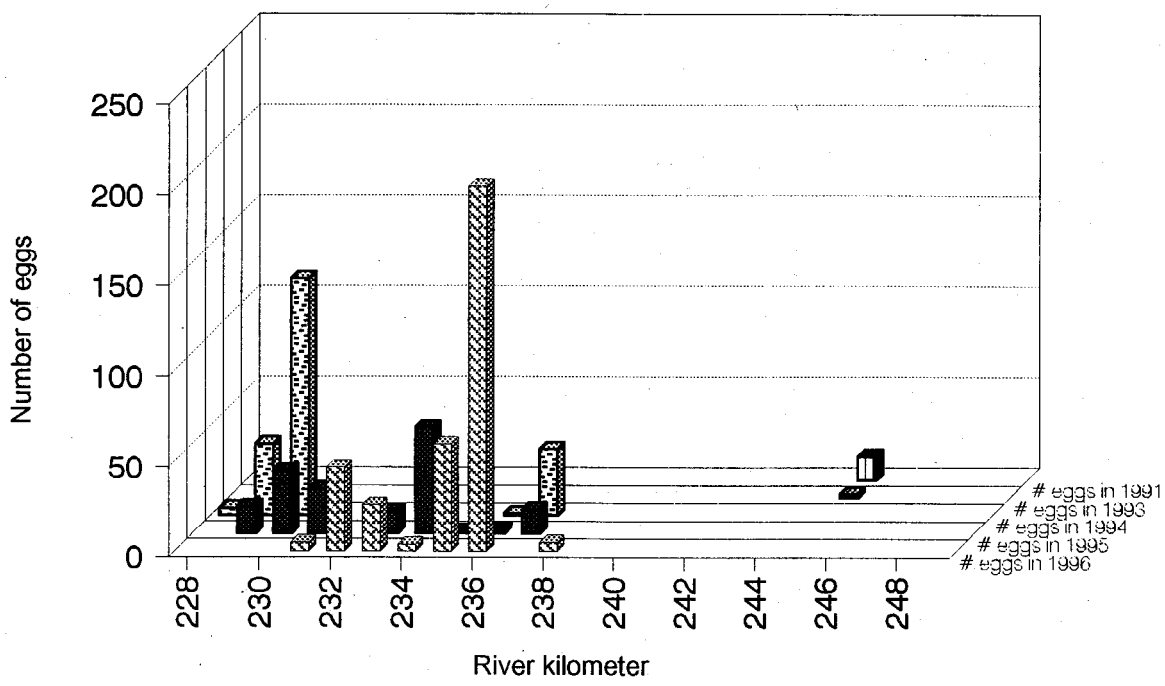
[a] One of these was a hatched-out eggshell .
[b] .2 of total depth.
° .8 of total depth.



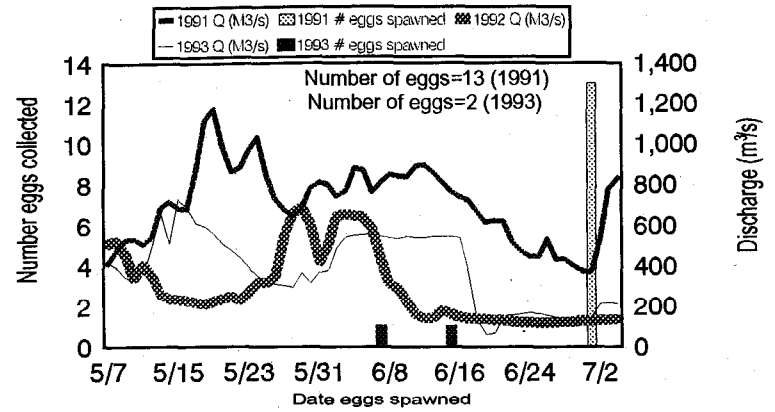


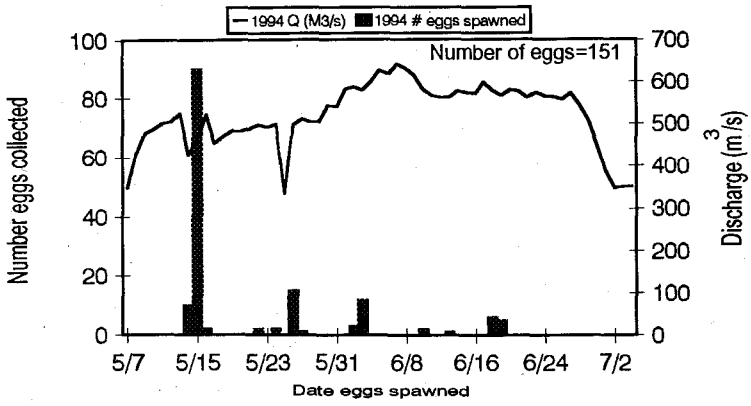


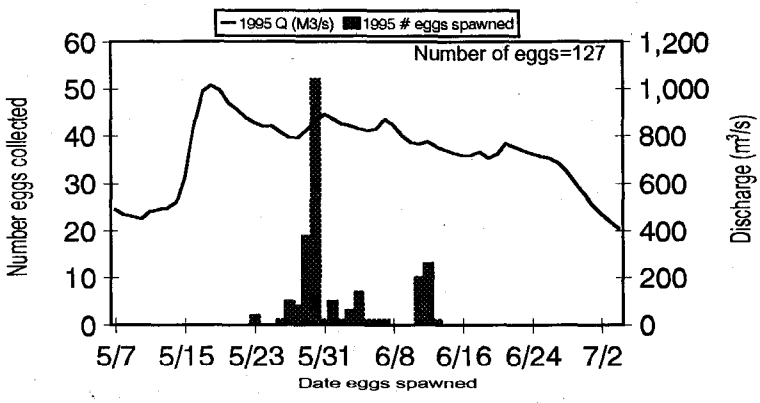
Appendix F. Habitat suitability curves (Parsley and Beckman 1994) and habitats used by white sturgeon in the Kootenai River, Idaho, 1991-1996. Top figure is current velocity, middle figure is temperature and bottom figure is depth.

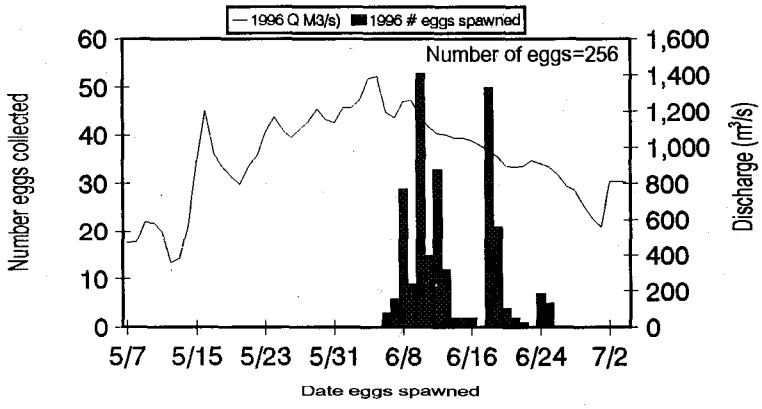


Appendix G. White sturgeon egg collection locations from the Kootenai River, Bonners Ferry, Idaho, 1991-1996.

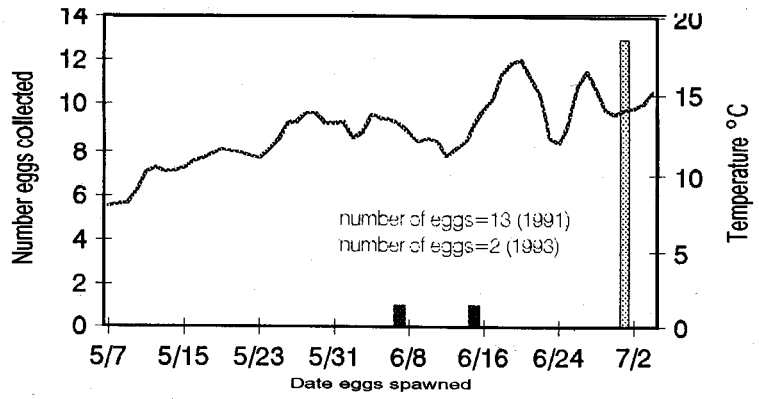


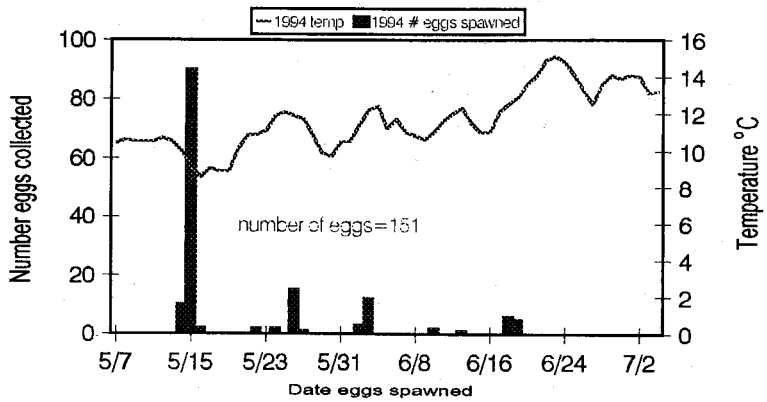


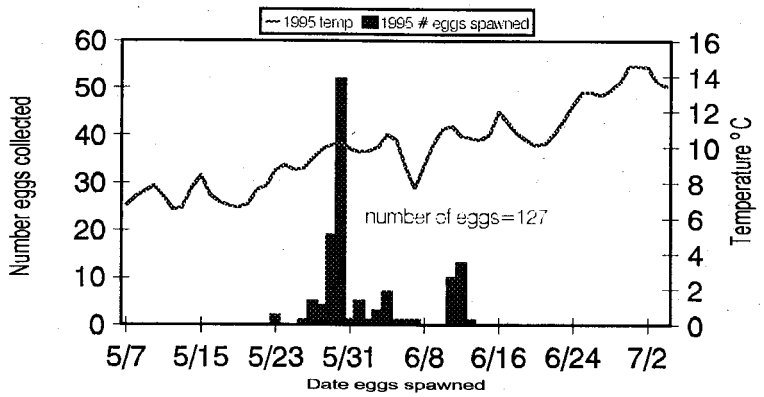


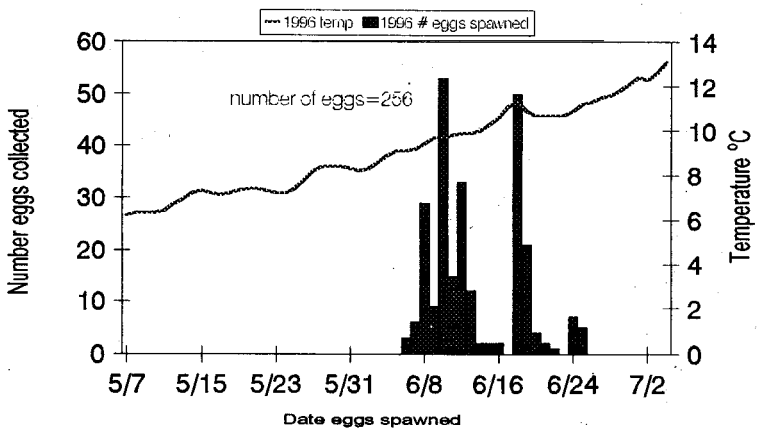


Appendix H. Top figure is date eggs were spawned, number of eggs collected that were spawned on that date, and discharge for 1991-1993. No eggs were collected in 1992. The bottom three figures are date eggs were spawned, number of eggs collected that were spawned on that date, and discharge for 1994-1996, consecutively.









Appendix I. Top figure is date eggs were spawned, number of eggs collected that were spawned on that date in 1991 and 1993. No eggs were collected in 1992. Temperature data is only shown for 1993 because it is not available for 1991 or 1992. The lower three figures are date eggs were spawned, number of eggs collected that were spawned on that date, and temperature for 1994-1996, consecutively.

Appendix J. Number of eggs, number of mats, flow (m^3/s), temperature (°C) and stage of egg development for white sturgeon eggs collected at Upper Shorty's Island (rkm 231.6-233.4), Kootenai River, Idaho, 1996.

Date	Spawn Date	No. Of Eggs	No. Of Mats	Flow (m'/s)	Temp	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6/9	6/8 6/9	20	2	1,260	9.7	8					2		1	9								
6/10	6/8	13	1	1,173	9.7	6									1	6						
6/11	6/9 6/9 6/10	13	1	1,113	9.8	3								1		4	5					
6/14	6/10 6/12	9	1	1,054	10	3										1		4	1			
Total		55	5																			

Appendix J. _ Continued. _ Myrtle Creek (rkm 233.5-234.7)

Date	Spawn Date	No. of Eggs	No. of Mats	Flow (m^3/s)	Temp	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6/8	6/6 6/7 6/8	10	2	1,257	9.4	2			1		1		1	2	2							
6/9	6/7 6/8 6/9	7	2	1,260	9.7					1	1	3										
6/10	6/7 6/8 6/10	3	2	1,173	9.7					1							1					
6/11	6/10	6	1	1,113	9.8	1					1		2	1								
6/14		1	1	1,054	10	1																
Total		27	8																			

Appendix J. Continued. Kootenai River National Wildlife Refuge (rkm 234.8-237.5)

Date	Spawn Date	No. of Eggs	No. of Mats	Flow (m^3/s)	Temp	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6/10	6/9 6/10	6	2	1,173	9.7	2	2				1	1										
6/11	6/10 6/11	58	5	1,113	9.8	7	12				1	1	14	23								
6/12	6/10 6/11 6/12	36	3	1,076	9.9	5	27						1	2		1						
6/13	--	1	1	1,071	9.9	1																
6/14	6/12	3	2	1,054	10										2	1						
6/17	6/13 6/14 6/15	38	2	1,008	11.1	23												2	11		2	
6/18	--	1	1	986	11.3	1																
6/21	6/16 6/18 6/19 6/20 6/21	69	2	892	10.7	8				1				2		7	4	46			1	
6/22	6/19 6/20 6/21	21	2	898	10.7	5								1		1	2	12				
6/25	6/24 6/25	19	3	892	11.2	9				1	4	1							4			
6/26	6/22 6/24 6/25	8[8]	3	850	11.3	4										2			1			
6/29	6/20	1	1	677	11.8																	1
6/30	1	1	1	612	12.1	1																
Total		262	28																			

One egg was a hatched-out shell.

Appendix J. Continued. Deep Creek (rkm 237.6-240.5)

Date	Spawn Date	No. of Eggs	No. of Mats	Flow (m^3/s)	Temp	Dead	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6/16	6/13 6/14 6/16	**5**	1	1,0.37	10.6	1		1								2	1					
Total		5	1																			

Appendix K. Brood year, stock year, release site and recapture site for hatchery juvenile white sturgeon released into the Kootenai River, Idaho, and recaptured by IDFG between July 6, 1996 and August 31, 1996. n=45

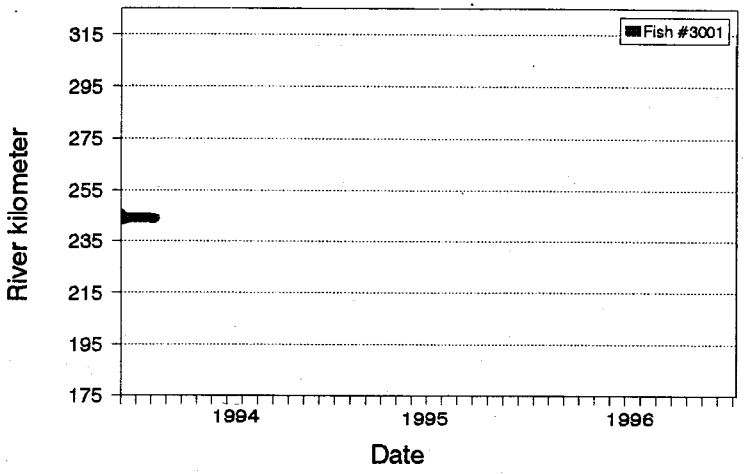
Fish #	Brood year	Stock year	Release rkm	Length at release FL/TL	Recapture date	Length at capture FLITL	Age at capture	Gear type	Recapture rkm
3022	1992	1994	309.3	62/72	7/21/96	63/75	4	Gill net	215.9
3033	1991	1992	243	19/22	7/6/96	45/53	5	Gill net	215
3044	1991	1992	243	23/26	7/17/96	47/56	5	Gill net	215.5
3047	1991	1992	243	22/23	7/16/96	50/59	5	Gill net	225
3049	1991	1992	243	23/27	7/16/96	44/54	5	Gill net	225.1
3049					7/29/96	45/55			225
3057	1991	1992	204	21/24	7/13/96	41/48	5	Gill net	215.6
3066	1991	1992	204	22/25	7/13/96	51/60	5	Gill net	215.6
3068	1991	1992	204	25/28	7/14/96	54/55	5	Gill net	205
3069	1991	1992	243	23/27	7/25/96	47/56	5	Gill net	205.5
3071	1991	1992	204	23/27	7/6/96	49/57	5	Gill net	215.6
3071					7/17/96	48/56			215.5
3075	1991	1992	243	21/24	7/8/96	46/55	5	Gill net	224.7
3079	1991	1992	204	19/27	7/14/96	47/55	5	Gill net	205
3083	1991	1992	204	24/28	7/13/96	56/61	5	Gill net	215.5
3086	1991	1992	204	24/27	7/6/96	53/62	5	Gill net	215
3095	1991	1992	243	23/26	7/6/96	50/59	5	Gill net	215
3105	1991	1992	204	22/26	7/31/96	47/56	5	Gill net	215.3
3106	1991	1992	243	23/26	7/16/96	48/56	5	Gill net	225
3111	1991	1992	204	21/24	7/13/96	50/59	5	Gill net	215.5
3114	1991	1992	- 243	22/25	7/26/96	44/51	5	Gill net	216

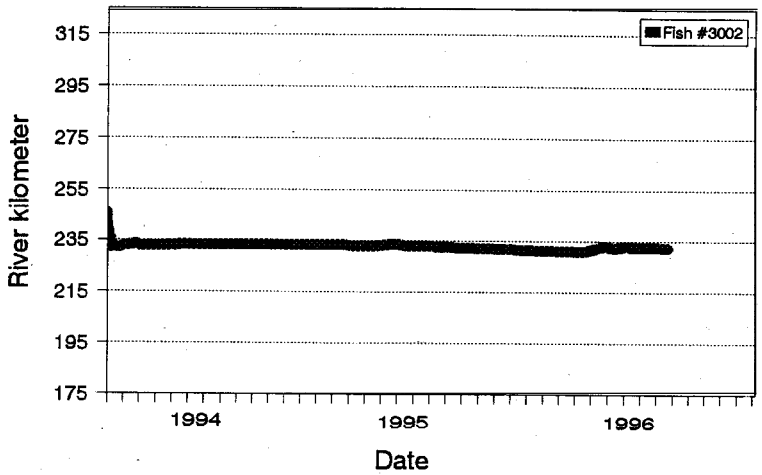
Appendix K. Continued.

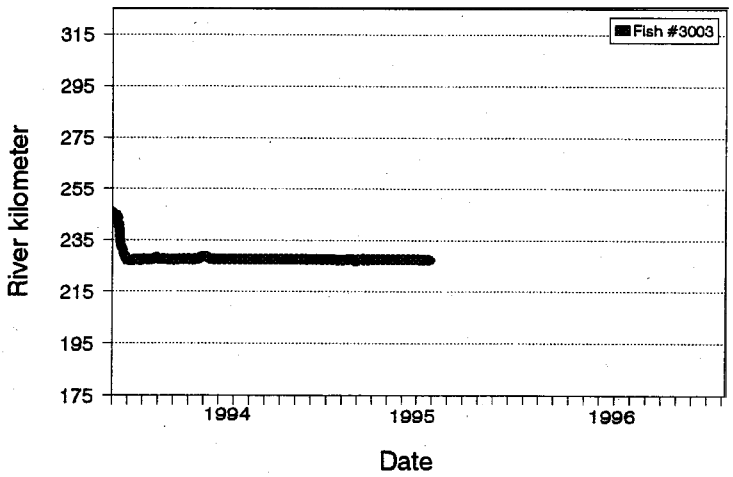
Fish #	Brood year	Stock year	Release rkm	Length at release FL/TL	Recapture date	Length at capture FL/TL	Age at capture	Gear type	Recapture rkm
3115	1991	1992	204	21/24	7/17/96	**45/53**	5	Gill net	215.6 `
3121	1991	1992	243	23/27	7/16/96	48/58	5	Gill net	224.6
3122	1991	1992	243	22/26	7/29/96	45/56	5	Gill net	225
3128	1991	1992	243	21/25	7/29/96	39/46	5	Gill net	225.1
3129	1991	1992	243	21/26	7/16//96	42/50	5	Gill net	224.9
3138	1992	1994	244.6	32/37	7/10/96	42/49	4	Gill net	227.8
3027	1992	1994	304.5	59/76	7/29/96	62/73	4	Gill net	225.1
3197	1992	1994	ND	38/43	7/9/96	50/90	4	Gill net	205.3
3200	1992	1994	ND	37/43	7/17/96	51/62	4	Gill net	215.6
3225	1992	1994	ND	41/47	7/14/96	49/58	4	Gill net	205
3224	1992	1994	ND	42/49	7/9/96	52/62	4	Gill net	203.5
3158	1992	1994	204	ND	7/6/96	55/66	4	Gill net	215.4
3017	1990	1992	204	ND	7/22/96	61/74	6	Gill net	205
3163	1991	1994	204	ND	7/14/96	55/63	5	Gill net	205
3168 3168	1992	1994	241.5	35/41	7/8/96 7/18/96	46/55 47/56	4	Gill net	229 225.1
3005	1992	1994	203.6	60/71	7/13/96	62/75	4	Gill net	215.6
3208	1992	1994	ND	40/46	7/13/96	51/60	4	Gill net	215.5
3174	1992	1994	241.5	30/35	7/13/96	45/52	4	Gill net	215.6

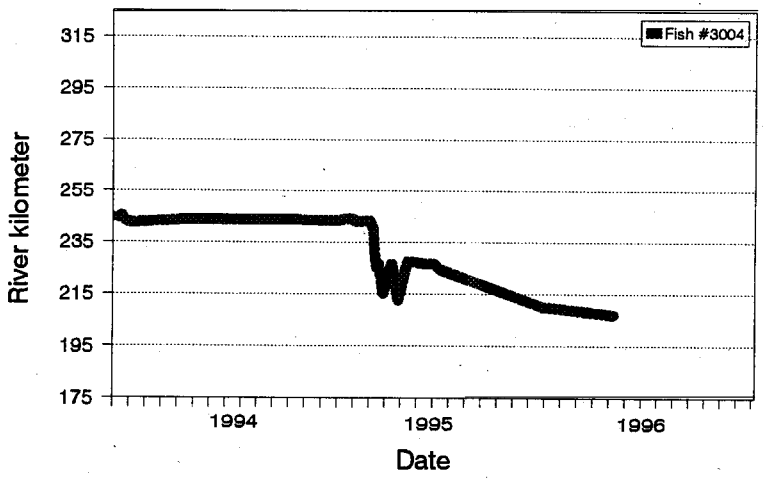
Appendix K. Continued.

Fish #	Brood year	Stock year	Release rkm	Length at release FL/TL	Recapture date	Length at capture FL/TL	Age at capture	Gear type	Recapture rkm
3198	1992	1994	ND	41/47	8/1/96	54/64	4	Gill net	205.6
3247	1992	1994	ND	36/41	8/6/96	49/57	4	Gill net	205.5
3182	1992	1994	203.6	58/69	8/1/96	62/75	4	Gill net	205.4
3025	1992	1994	310.4	62/74	7/25/96	64/76	4	Gill net	205.5
3030	1992	1994	304.5	64/74	7/14/96	64/72	4	Gill net	205

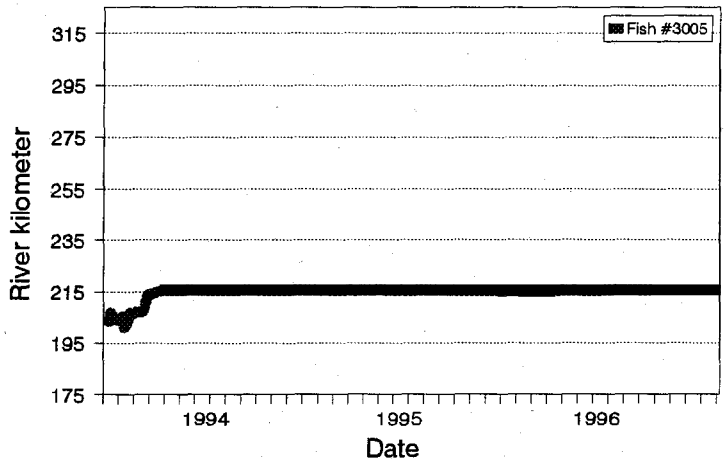


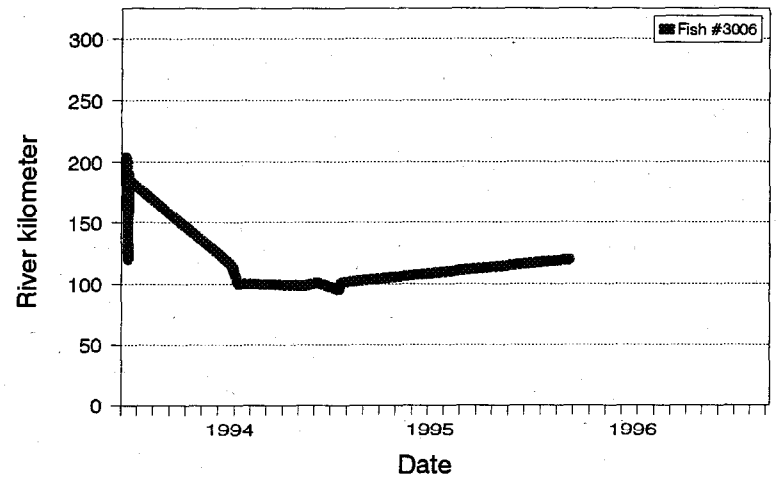


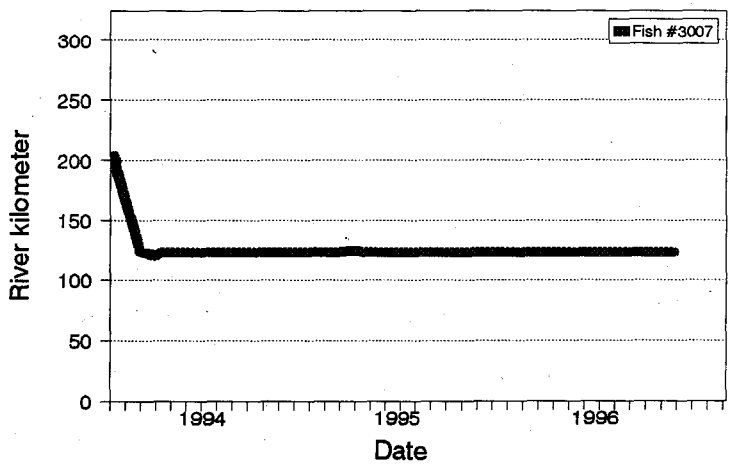


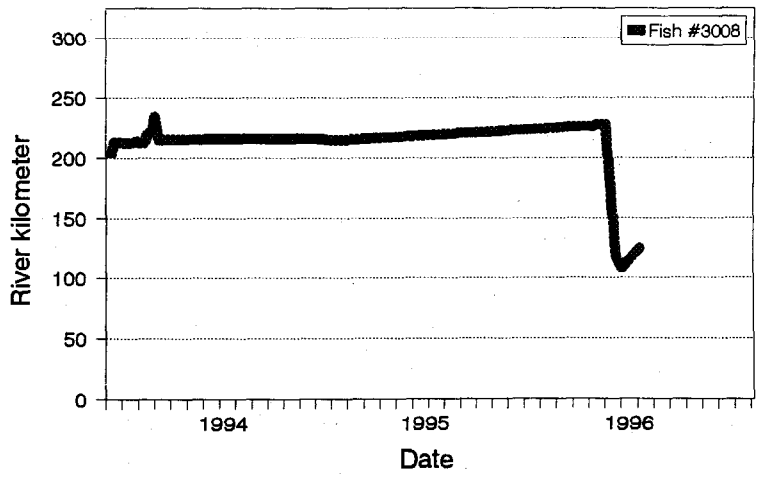


Appendix L. Juvenile white sturgeon movement in the Kootenai River, ID and Kootenay Lake, BC from 1994 to 1996.

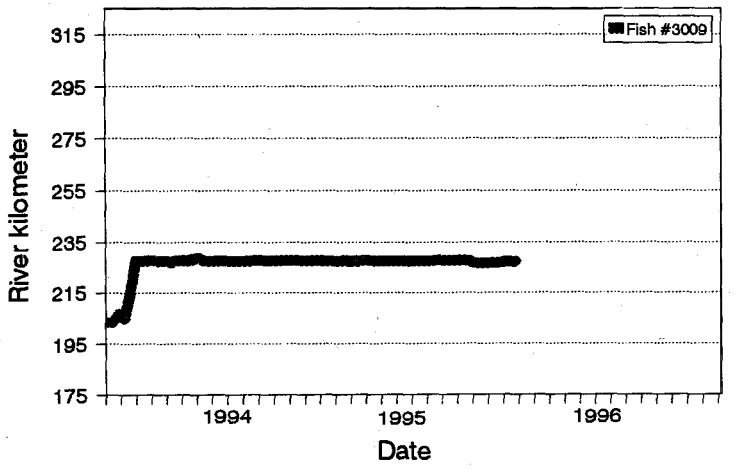


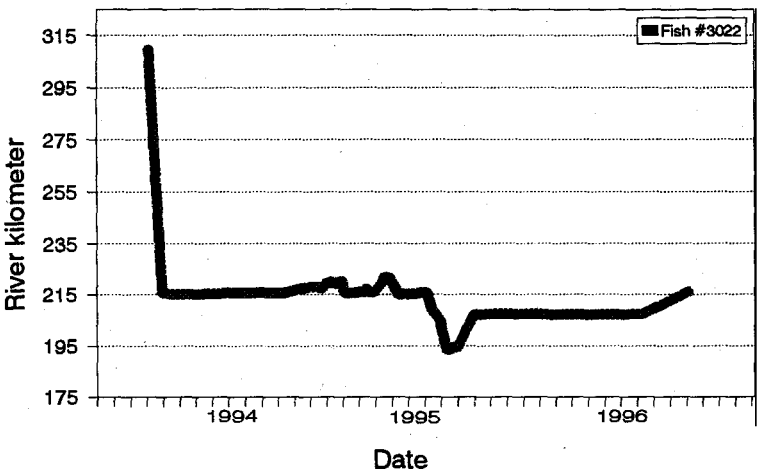


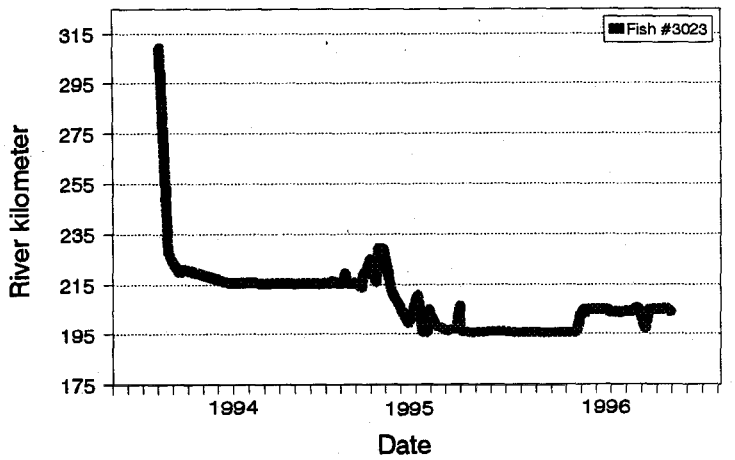


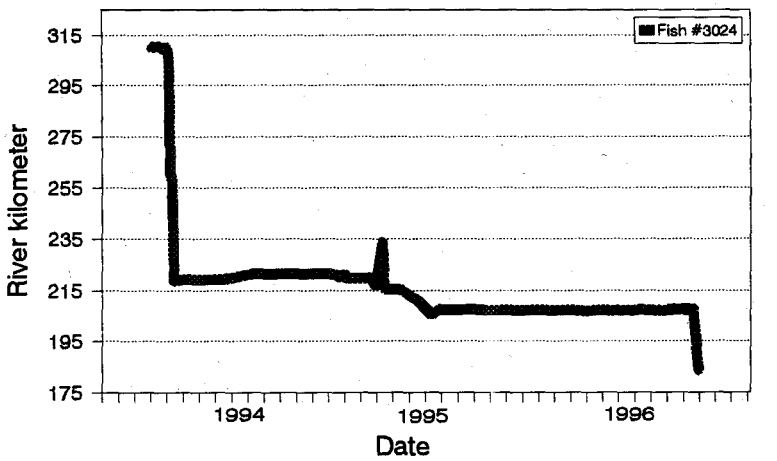


Appendix L. Continued.

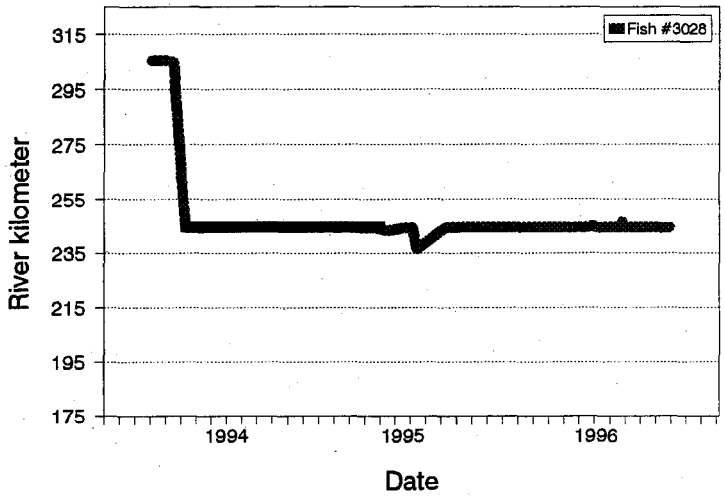


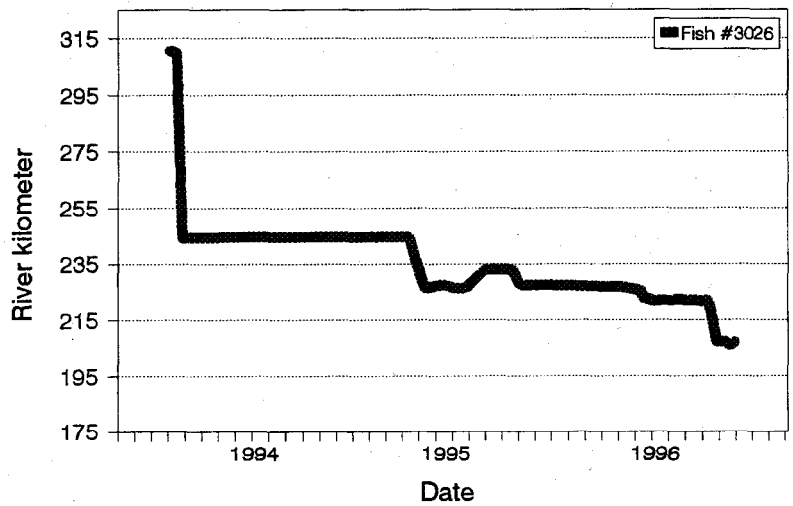


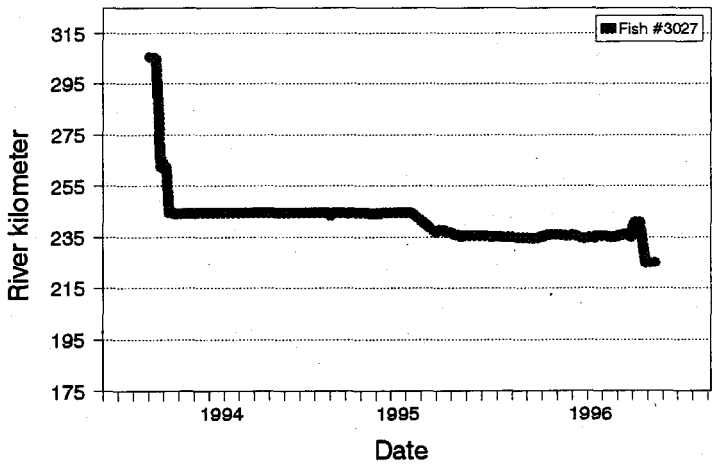


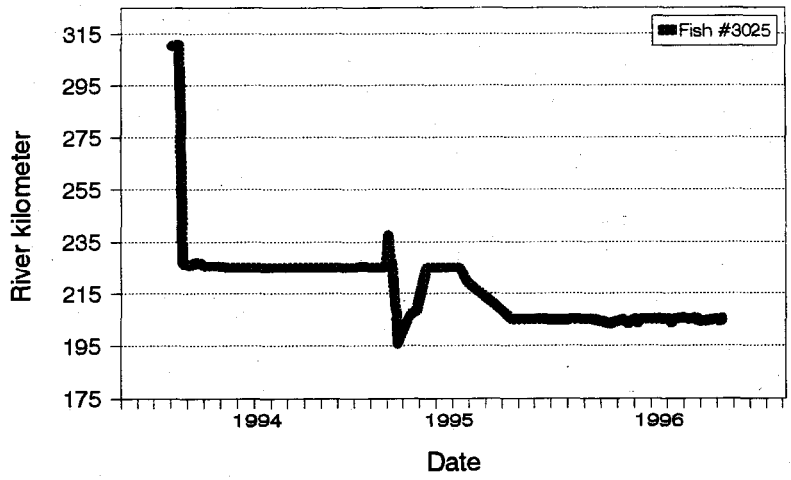


Appendix L. Continued.

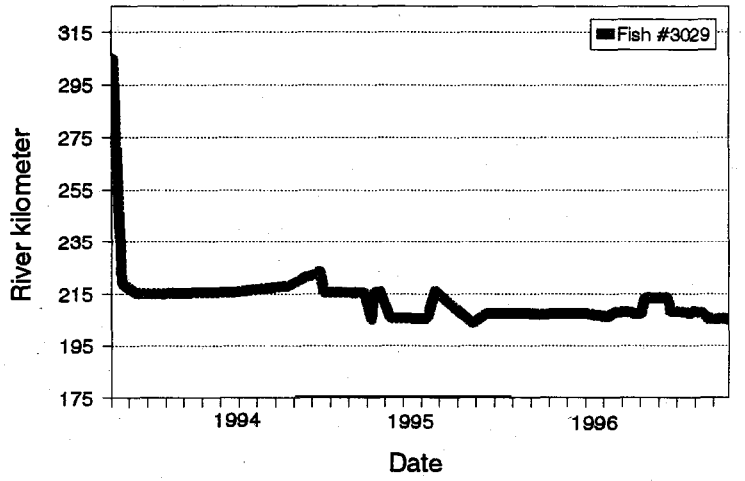


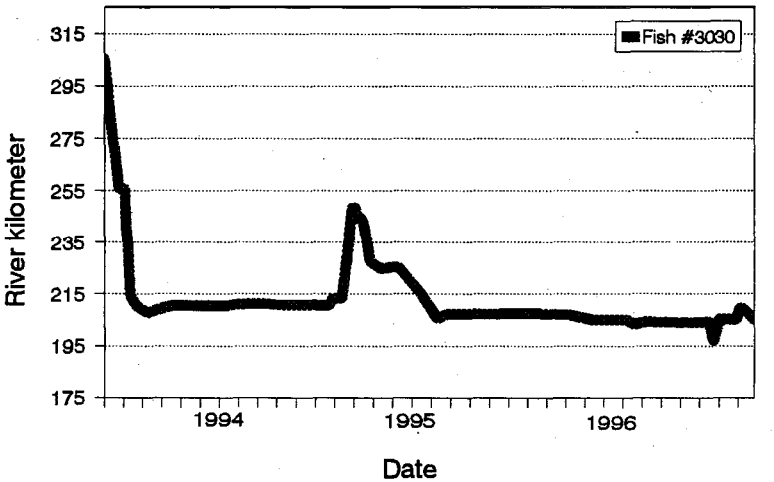


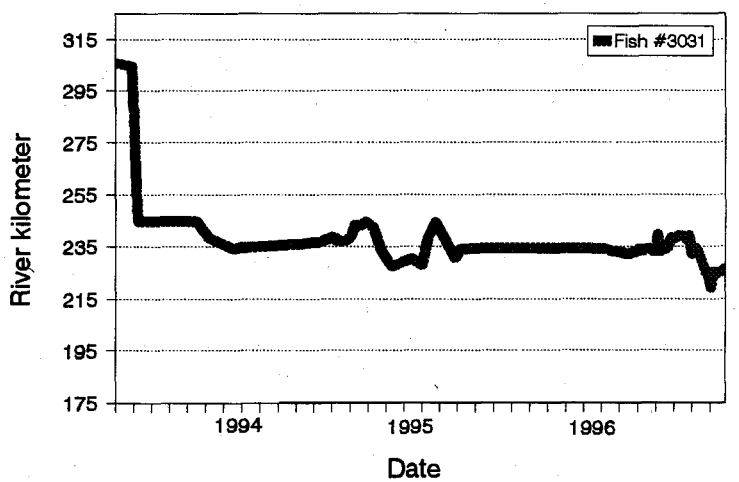




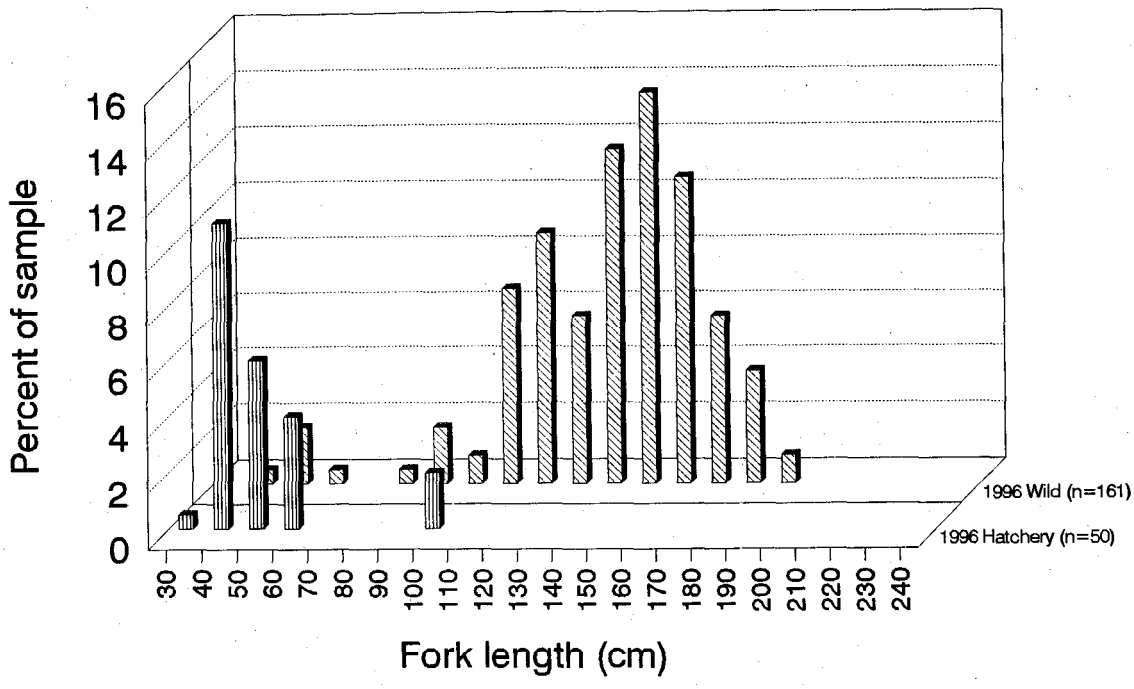
Appendix L. Continued.

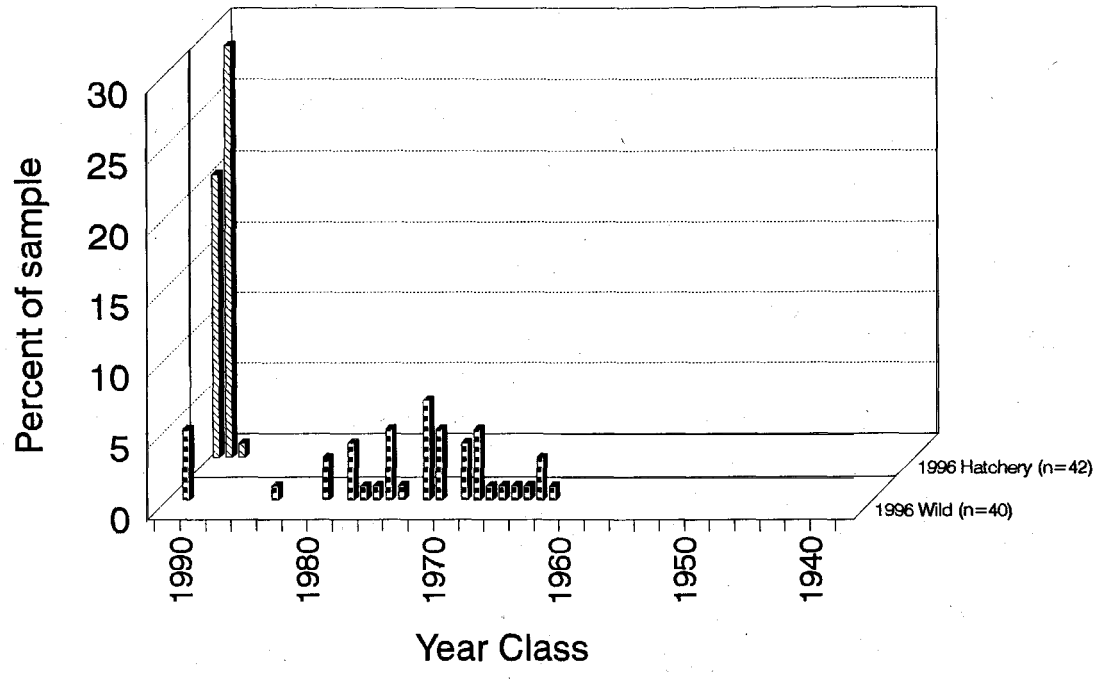






Appendix L. Continued.





Appendix M. Top figure is percent of fish in each length frequency category for white sturgeon captured in 1996. Bottom figure is percent of fish in each year class for white sturgeon captured in 1996.

Appendix N. Top table is age, year class and number of hatchery reared white sturgeon captured by IDFG in the Kootenai River, Idaho, 1996 (n=45[8]). Bottom table is age, year class and number of wild white sturgeon captured by IDFG in the Kootenai River, Idaho, 1996 (n=41).

Number of fish (Number aged)	**Age**	**Year class**
1 (1)	6	1990
27[a] (7)	5	1991
17 (3)	4	1992

[a] Three of these fish were captured twice.

Number of fish (n=37)	**Age**	**Year class**
1	34	1962
2	33	1963
1	32	1964
1	31	1965
1	30	1966
1	29	1967
4	28	1968
3	27	1969
4	25	1971
6	24	1972
1	22	1974
4	21	1975
1	20	1976
1	19	1977
3	18	1978
2	16	1980
1	12	1984
4	6	1991

Submitted by:

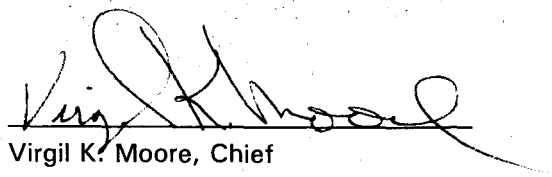
Vaughn L. Paragamian
Senior Fishery Research Biologist

Gretchen Kruse
Senior Fishery Technician

Virginia Wakkinen
Fishery Technician

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME



Virgil K. Moore, Chief
Bureau of Fisheries